Instruction Manual

42646-1

MODEL

2175A

DIGITAL THERMOMETER

FLUKE®

JOHN FLUKE mfg. co., inc.

SEATTLE, WASHINGTON

Instruction Manual

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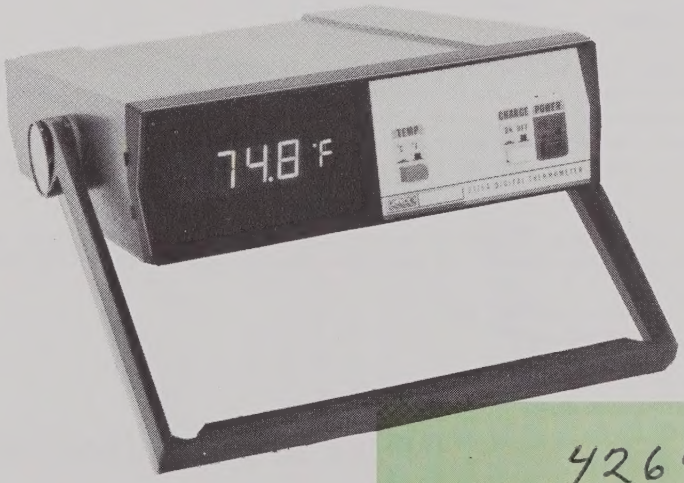
JOHN FLUKE MFG. CO., INC.

P. O. Box 43210
Mountlake Terrace, Washington 98043



42646-1

MODEL

2175A

DIGITAL THERMOMETER

3-23-78

P/N 445478
APRIL, 1976

WARRANTY

The JOHN FLUKE MFG. CO., INC.* warrants each instrument manufactured by them to be free from defects in material and workmanship. Their obligation under this Warranty is limited to servicing or adjusting an instrument returned to the factory for that purpose, and to making good at the factory any part or parts thereof; except tubes, fuses, choppers and batteries, which shall, within one year after making delivery to the original purchaser, be returned by the original purchaser with transportation charges prepaid, and which upon their examination shall disclose to their satisfaction to have been thus defective. If the fault has been caused by misuse or abnormal conditions of operations, repairs will be billed at a nominal cost. In this case, an estimate will be submitted before work is started, if requested.

If any fault develops, the following steps should be taken:

1. Notify the John Fluke Mfg. Co., Inc.,* giving full details of the difficulty, and include the Model number, type number, and serial number. On receipt of this information, service data or shipping instructions will be forwarded to you.

2. On receipt of the shipping instructions, forward the instrument prepaid, and repairs will be made at the factory. If requested, an estimate will be made before the work begins, provided the instrument is not covered by the Warranty.

"The foregoing warranty is in lieu of all other warranties, express or implied, including but not limited to, any implied warranty of merchantability, fitness or adequacy for any particular purpose or use. Fluke shall not be liable for any special, incident or consequential damages."

SHIPPING

All shipments of John Fluke Mfg. Co., Inc.* instruments should be made via United Parcel Service or "Best Way"** prepaid. The instrument should be shipped in the original packing carton; or if it is not available, use any suitable container that is rigid. If a substitute container is used, the instrument should be wrapped in paper and surrounded with at least four inches of excelsior or similar shock-absorbing material.

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be thoroughly inspected immediately upon receipt. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing sheet unless notified immediately. If the instrument fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to John Fluke Mfg. Co., Inc.* Upon receipt of this report, you will be advised of the disposition of the equipment for repair or replacement. Include the model number, type number, and serial number when referring to this instrument for any reason.

The John Fluke Mfg. Co., Inc.* will be happy to answer all application questions which will enhance your use of this instrument. Please address your requests to: JOHN FLUKE MFG. CO., INC., P.O. Box 43210, MOUNTLAKE TERRACE, WASHINGTON 98043*.

* For European customers: FLUKE (Nederland) B.V.
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Tilburg, Netherlands

** For European customers, Air Freight prepaid.

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Rev. 11/75

CHANGE/ERRATA INFORMATION

MANUAL — TITLE: DIGITAL THERMOMETERS
2160A, 2170A, 2165A, 2175A, 2166A, 2176A, 2168A
ISSUE: APRIL 1976

Please make changes in this manual according to the following change and/or errata information:

ERRATA

In each of the instruction manuals listed below, add the following warning prior to paragraph 2-1, in Section 2. Insert the appropriate paragraph numbers (given below) in the space provided in the warning.

INSTRUCTION MANUAL	PARAGRAPHS
2160A	2-17, 2-21 and 2-23
2170A	2-17, 2-21 and 2-23
2165A	2-17 and 2-21
2175A	2-17 and 2-21
2166A	2-21 and 2-27
2176A	2-21 and 2-27
2168A	2-21

Insert appropriate paragraph nos.

WARNING!

Due to the possible presence of lethal voltages, the procedure(s) in paragraph(s) _____ should be performed by qualified personnel only.

Table of Contents

SECTION	TITLE	PAGE
1	**INTRODUCTION ANS SPECIFICATIONS**	**1-1**
	1-1. INTRODUCTION	1-1
	1-9. SPECIFICATIONS	1-2
2	**OPERATING INSTRUCTIONS**	**2-1**
	2-1. INTRODUCTION	2-1
	2-3. SHIPPING INFORMATION	2-1
	2-6. INPUT POWER	2-1
	2-9. RACK INSTALLATION	2-1
	2-11. OPERATING FEATURES	2-1
	2-13. OPERATING NOTES	2-1
	2-15. Option Information	2-1
	2-17. Fuse Replacement	2-1
	2-19. Overload and Open Thermocouple Indication	2-3
	2-21. Thermocouple Compatibility	2-3
	2-23. CHARGE Switch	2-4
	2-25. OPERATION	2-4
3	**THEORY OF OPERATION**	**3-1**
	3-1. INTRODUCTION	3-1
	3-3. OVERALL FUNCTIONAL DESCRIPTION	3-1
	3-7. CIRCUIT ANALYSIS	3-2
	3-9. Digital Section	3-2
	3-14. Analog Section	3-3
4	**MAINTENANCE**	**4-1**
	4-1. INTRODUCTION	4-1
	4-3. SERVICE INFORMATION	4-1
	4-6. GENERAL MAINTENANCE	4-1
	4-7. Access Information	4-1
	4-9. Cleaning	4-2
	4-11. Fuse Replacement	4-2
	4-13. Service Tools	4-2
	4-15. PERFORMANCE TEST	4-2
	4-17. Initial Procedure	4-2

(continued on page ii)

TABLE OF CONTENTS, *continued*

SECTION		TITLE	PAGE
	4-19.	Line Voltage Regulation	4-2
	4-21.	Accuracy Test	4-4
	4-23.	Overload and Open Input	4-4
	4-25.	Internal Temperature Rise	4-4
	4-27.	CALIBRATION	4-5
	4-32.	TROUBLESHOOTING	4-7
5		**LISTS OF REPLACEABLE PARTS**	**5-1**
	5-1.	INTRODUCTION	5-2
	5-4.	HOW TO OBTAIN PARTS	5-2
	5-7.	USE CODE EFFECTIVITY LIST	5-2
6		**OPTION AND ACCESSORY INFORMATION**	**6-1**
	6-1.	INTRODUCTION	6-1
	6-3.	CARRYING CASE (C80)	6-1
	6-5.	CARRYING CASE (C86)	6-2
	6-7.	THERMOCOUPLE PROBES	6-2
	6-9.	FRONT PANEL DUST COVER (M00-100-714)	6-2
	6-11.	RACK MOUNTING KITS	6-2
	6-13.	TYPE SELECT PCB's	6-2
	6-15.	INTERFACE CABLE (2160A-7022)	6-2
	6-17.	BATTERY PACK, OPTION –01	6-2
	6-19.	Installation	6-2
	6-21.	Charging Ni-Cad Batteries	6-3/6-4
	6-25.	DIGITAL OUTPUT UNIT, OPTION –02	6-3/6-4
	6-28.	ANALOG OUTPUT UNIT, OPTION –04	
7		**GENERAL INFORMATION**	**7-1**
8		**SCHEMATIC DIAGRAMS**	**8-1**

List of Illustrations

FIGURE	TITLE	PAGE
1-1.	Outline Drawing	1-4
2-1.	Controls, Indicators and Connectors	2-2
2-2.	Type Select PCB, Location and Installation Details	2-4
3-1.	2175A Simplified Block Diagram	3-1
3-2.	Measurement Cycle Waveforms	3-2
3-3.	Analog Section, Simplified Circuit Diagram	3-3
4-1.	Performance - Test Equipment Connections	4-3
4-2.	Test Point and Adjustment Locations	4-6
4-3.	Equipment Connections	4-7
6-1.	C80 Carrying Case	6-1
6-2.	C86 Carrying Case	6-2
6-3.	P20 Series Probe	6-2
8-1.	A1A1 Thermometer PCB Assembly (2175A-1001) (2 sheets)	8-2
8-2.	A2 Display PCB Assembly (2165A-1002) (2 sheets)	8-4
8-3.	A3 Type Select PCB Assembly (2160A-1012)	8-6

List of Tables

TABLE	TITLE	PAGE
1-1.	2175A Accessories	1-1
1-2.	2175A Options	1-2
1-3.	Specifications	1-2
2-1.	2175A Controls, Indicators and Connectors	2-3
4-1.	Test Equipment Requirements	4-1
4-2.	Performance Description	4-2
4-3.	Temperature Accuracy	4-4
4-4.	Full Scale Calibration	4-5
4-5.	Troubleshooting Guide	4-8
6-1.	Options, Accessories and Documentation Sources	6-1
7-1.	List of Abbreviations	7-1
7-2.	Federal Supply Codes for Manufacturers	7-3
7-3.	Fluke Technical Service Centers	7-10
7-4.	Sales Representatives - Domestic	7-11
7-5.	Sales Representatives - International	7-13

Section 1
Introduction & Specifications

1-1. INTRODUCTION

1-2. The Model 2175A Digital Thermometer is a portable, four-digit, thermocouple thermometer capable of resolving 0.2°C or 0.2°F over a temperature range of –99.8 to 999.8°C or –99.8 to 999.8°F. It features push-button selection of °C or °F, a four digit LED display, reference junction compensation (to eliminate the need for an ice bath reference junction), the choice of using any one-of-four thermocouple types (J, K, E or T) as the input device, dual-slope measurement techniques and digital linearization of the thermocouple inputs. Several options and accessories are also available for use with the 2175A.

1-3. Push button controls include a power switch (ON/OFF), a temperature scale switch (°C/°F) and a charge switch (ON/OFF). The charge switch is enabled when the unit is equipped with the Battery Option (–01), and enables the selection of trickle charge (OFF) or full charge (ON) when the unit is connected to line power.

1-4. The front-panel display consists of five, seven-segment high-intensity LED's, and features leading-zero suppression. Four of the LED's are used to display numeric data, including a minus sign for negative temperature indications. The fifth LED displays the selected °C or °F scale character. An open-thermocouple detector causes the display to blink when an open circuit is sensed at the thermocouple input terminals.

1-5. Rear-panel, screw-type input connectors are provided for attaching the selected thermocouple. These terminals are an integral part of an isothermal block and serve as the reference junction for the reference-junction compensator. (The reference-junction compensator provides the physical and electrical equivalent of, and eliminates the need for, an ice bath reference junction at 0°C or 32°F.)

1-6. The actual measurement range of the 2175A is determined by the type of thermocouple being used as the input device. Any one of four thermocouple types can be used; J, K, E or T. To ensure the proper linearization of the selected thermocouple input, a corresponding linearization program must be selected on the interior of the unit. Selection is accomplished by installing a type select pcb which corresponds to the input thermocouple. A single type select pcb is supplied with the unit to match the thermocouple type specified at the time of purchase. The remaining pcbs are individually available as accessories and are described in Table 1-1.

Table 1-1. 2175A ACCESSORIES

MODEL NO.	DESCRIPTION
C80	Carrying Case
C86	Carrying Case
P20J	J-Type Thermocouple Probe
P20K	K-Type Thermocouple Probe
P20T	T-Type Thermocouple Probe
M00-100-714	Front Panel Dust Cover
M00-200-611	Rack Mounting Kit, Offset
M00-200-612	Rack Mounting Kit, Center
M00-200-613	Rack Mounting Kit, Side-by-Side
2160A-7016	J-Type Select PCB
2160A-7017	K-Type Select PCB
2160A-7019	E-Type Select PCB
2160A-7018	T-Type Select PCB
2160A-7022	Interface Cable

1-7. Accessories and Options available for use with the 2175A are listed and described in Table 1-1 and 1-2, respectively. Detailed information concerning each option and accessory is given in Section 6 of this manual, Option and Accessory Information.

Table 1-2. 2175A OPTIONS

OPTION NO.	DESCRIPTION	COMPATIBILITY		
		–01	–02	–04
–01	Rechargeable Batteries	–	YES	YES
–02	Digital Output Unit	YES	–	NO
–04	Analog Output Unit	YES	NO	–

1-8. The 2175A is available in any one-of-three line power configurations: 100V ac, 50 to 440 Hz; 115V ac, 50 to 440 Hz; and 230V ac, 50 to 440 Hz. Specify the required configuraiton at the time of purchase.

1-9. SPECIFICATIONS

1-10. Specifications for the 2175A are given in Table 1-3.

Table 1-3. SPECIFICATIONS

ELECTRICAL

Compatible Thermocouple Types . . . . Unit can be calibrated to operate with any one of the following thermocouple types: J, K, T, E

Measurement Method . . . . . Dual-slope integration over a 100 ms period.

Zero Drift . . . . . None. Automatic zero correction.

Reading Rate . . . . . 2.5 readings per second

°C to °F Conversion . . . . . Switch selectable

Input Characteristics

Input Connections . . . . . Screw terminals on isothermal connector.

Input Circuit . . . . . Two-wire, isolated

Input Impedance . . . . . $> 100\ M\Omega$

Input Current . . . . . < 500 pA

Source Impedance . . . . . $\leq 5k\Omega$. $5k\Omega$ causes $< 0.2°C$ error with k thermocouple.

Overload . . . . . Display flashes when input voltage exceeds full-scale temperature range.

Open Input . . . . . Display flashes to indicate open at input terminals.

Maximum Input Voltage (without damage) . . . . . 400V dc or ac peak continuously between inputs or either input and ground.

Maximum Common Mode Voltage (without damage) . . 400V dc or ac peak.

Common Mode Rejection . . . . . ≥ 120 dB @ 50, 60, 400 Hz $\pm 0.1\%$ with $1k\Omega$ source impedance unbalance.

Normal Mode Rejection . . . . . ≥ 60 dB @ 50, 60, 400 Hz $\pm 0.1\%$

Accuracy . . . . . See Table 1 for °C specifications and Table 2 for °F specifications.

Response Time to Rated Accuracy . . . . < 2.0 seconds

Linearization . . . . . Digital with four selectable programs in LSI ROM.

Linearization Programs

J, K, T and E . . . . . 32 straight line segments for positive inputs and 16 for negative inputs.

Table 1-3. SPECIFICATIONS (Cont.)

Reference Junction Compensation

20 to 30°C

J, K, T, E . . . . . 0.025 degrees per degree

0 to 20°C, 30 to 50°C

J, K . . . . . 0.032 degrees per degree

T, E . . . . . 0.045 degrees per degree

Temperature Coefficient . . . . . 0.005% of reading per °C

Internal Temperature Rise . . . . . ⩽8°C

Table 1- . ACCURACY SPECIFICATIONS °C

THERMOCOUPLE TYPE	TEMPERATURE RANGE C	RESOLUTION AND REPEATABILITY (± C)	APPLICABLE TEMPERATURE RANGE C	MAXIMUM ERROR INCLUDING NBS CONFORMITY (± C)				NBS CONFORMITY (± C)
				CALIBRATION ACCURACY	20 min. to 24 hrs. 23 to 27 C	90 Days 20 to 30 C	1 Year 15 to 35 C	
J	–99.8 to 777.8	0.2	–99.8 to 0 0 to 777.8	0.5 0.4	0.7 0.5	1 0.7	1.2 1.1	0.19 0.15
K	–99.8 to 999.8	0.2	–99.8 to 0 0 to 999.8	0.7 0.5	0.8 0.6	1.2 1.1	1.5 1.4	0.2 0.18
T	–99.8 to 400	0.2	–99.8 to 0 0 to 400	0.6 0.4	0.6 0.5	1 0.6	1.6 0.9	0.19 0.15
E	–99.8 to 999.8	0.2	–99.8 to 0 0 to 999.8	0.6 0.5	0.7 0.6	1 1	1.7 1.4	0.17 0.18

*Includes reference junction and conformity errors. Excludes thermocouple errors.

Table 2- . ACCURACY SPECIFICATIONS °F

THERMOCOUPLE TYPE	TEMPERATURE RANGE F	RESOLUTION AND REPEATABILITY (± F)	APPLICABLE TEMPERATURE RANGE F	MAXIMUM ERROR INCLUDING NBS CONFORMITY (± F)				NBS CONFORMITY (± F)
				CALIBRATION ACCURACY	20 min. to 24 hrs. 72 to 81 F	90 Days 68 to 86 F	1 Year 59 to 95 F	
J	–99.8 to 999.8	0.2	–99.8 to 32 32 to 999.8	0.9 0.7	1 0.8	1.6 1.2	2.1 1.6	0.27 0.2
K	–99.8 to 999.8	0.2	–99.8 to 32 32 to 999.8	1.1 1	1.2 1	2.0 1.4	2.6 1.8	0.28 0.26
T	–99.8 to 752	0.2	–99.8 to 32 32 to 752	0.9 0.6	0.9 0.8	1.7 1	2.9 1.5	0.3 0.2
E	–99.8 to 999.8	0.2	–99.8 to 32 32 to 999.8	0.9 0.8	0.9 0.9	1.7 1.3	3.0 1.8	0.25 0.25

*Includes reference junction and conformity errors. Excludes thermocouple errors.

Table 1-3. SPECIFICATIONS (Cont.)

GENERAL

Type of Display	LED, 0.56 in high.
Power Requirements	
Line Operation	115V ac ±10%, 50 to 440 Hz, 8W. 100V ac and 230V ac versions are also available.
Battery Operation	4.8V dc @ 350 mA (Four internal, D-size, Ni-Cad batteries, –01 option). Eight hours of operation on a full charge.
Size	2.52 in (H) x 8.55 in (W) x 9.9 in (D) (6,40 cm x 21,72 cm x 25,25 cm). See Figure 1-1.
Weight	
Without Batteries	2 lbs. 10 oz. (1.19 kg)
With Batteries	3 lbs. 15 oz. (1.79 kg)

ENVIRONMENTAL

Operating	0 to 50°C (32 to +122°F)
Storage	
With Batteries	–40 to 60°C (–40 to 140°F)
Without Batteries	–40 to 75°C (–40 to 167°F)
Humidity	
0 to 50°C	80% non-condensing
0 to 35°C	90% non-condensing
Shock and Vibration	Meets requirements of MIL Standard 810

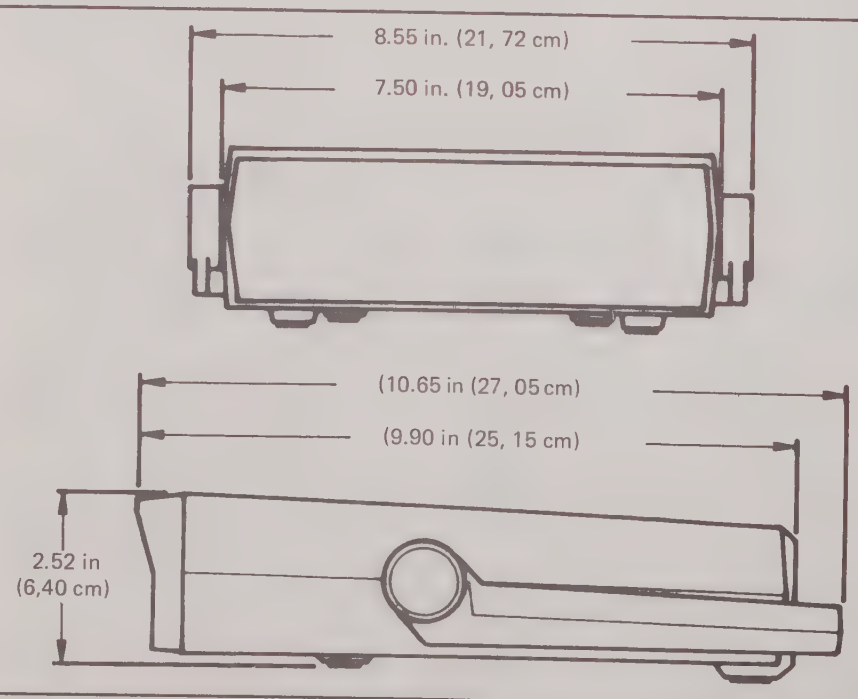


Figure 1-1. OUTLINE DRAWING

Section 2
Operating Instructions

2-1. INTRODUCTION

2-2. This section of the manual contains information regarding installation and operation of the Model 2175A Digital Thermometer. It is recommended that the contents of this section be read and understood before any attempt is made to operate the instrument. Should any difficulties arise during operation, please contact your nearest Fluke Technical Service Center, or the John Fluke Mfg. Co., Inc., P.O. Box 43210, Mountlake Terrace, WA 98043, Tel. (206) 774-2211. A list of Technical Service Centers is located in Section 7 of this manual.

2-3. SHIPPING INFORMATION

2-4. The 2175A is packaged and shipped in a foam-packed container. Upon receipt of the instrument, a thorough inspection should be made to reveal any possible shipping damage. Special instructions for inspection and claims are included in the shipping carton.

2-5. If reshipment of the instrument is necessary, the original container should be used. If the original container is not available, a new one can be obtained from the John Fluke Mfg. Co., Inc. Please reference the instrument model number when requesting a new shipping container.

2-6. INPUT POWER

2-7. The 2175A is factory wired to operate from one-of-three ac line voltages. These are: 100V ac, 50 to 440 Hz; 115V ac, 50 to 440 Hz; and 230V ac, 50 to 440 Hz. Before connecting the 2175A to the ac line, check to ensure that the instrument is wired to accommodate the local line voltage. A decal on the underside of the unit defines the particular line voltage required to operate the instrument.

2-8. The rear panel ac input connector is a three-prong, U-ground connector which permits the instrument to be connected, via the power cord, to the appropriate line voltage. The offset prong on this connector is connected to the 2175A power supply, and should be connected through the power cord to a high quality earth ground.

2-9. RACK INSTALLATION

2-10. The 2175A is designed for field and bench-top use or for installation in a standard 19-inch equipment rack using an accessory rack-mounting kit. Kits are available for left, right, center or side-by-side mounting of the 2175A. Information regarding installation of the rack mounting accessories is given in Section 6 of this manual, Option and Accessory Information.

2-11. OPERATING FEATURES

2-12. The location of all 2175A controls, indicators and connectors are shown in Figure 2-1, and described in Table 2-1.

2-13. OPERATING NOTES

2-14. The following paragraphs describe various conditions which should be considered before operating the 2175A.

2-15. Option Information

2-16. Supplementary operating instructions are necessary when operating a 2175A which is equipped with one of the available options. Detailed information regarding the operation of each available option is given in Section 6 of this manual, Option and Accessory Information.

2-17. Fuse Replacement

WARNING

Disconnect the unit from line power before attempting to replace the fuse.

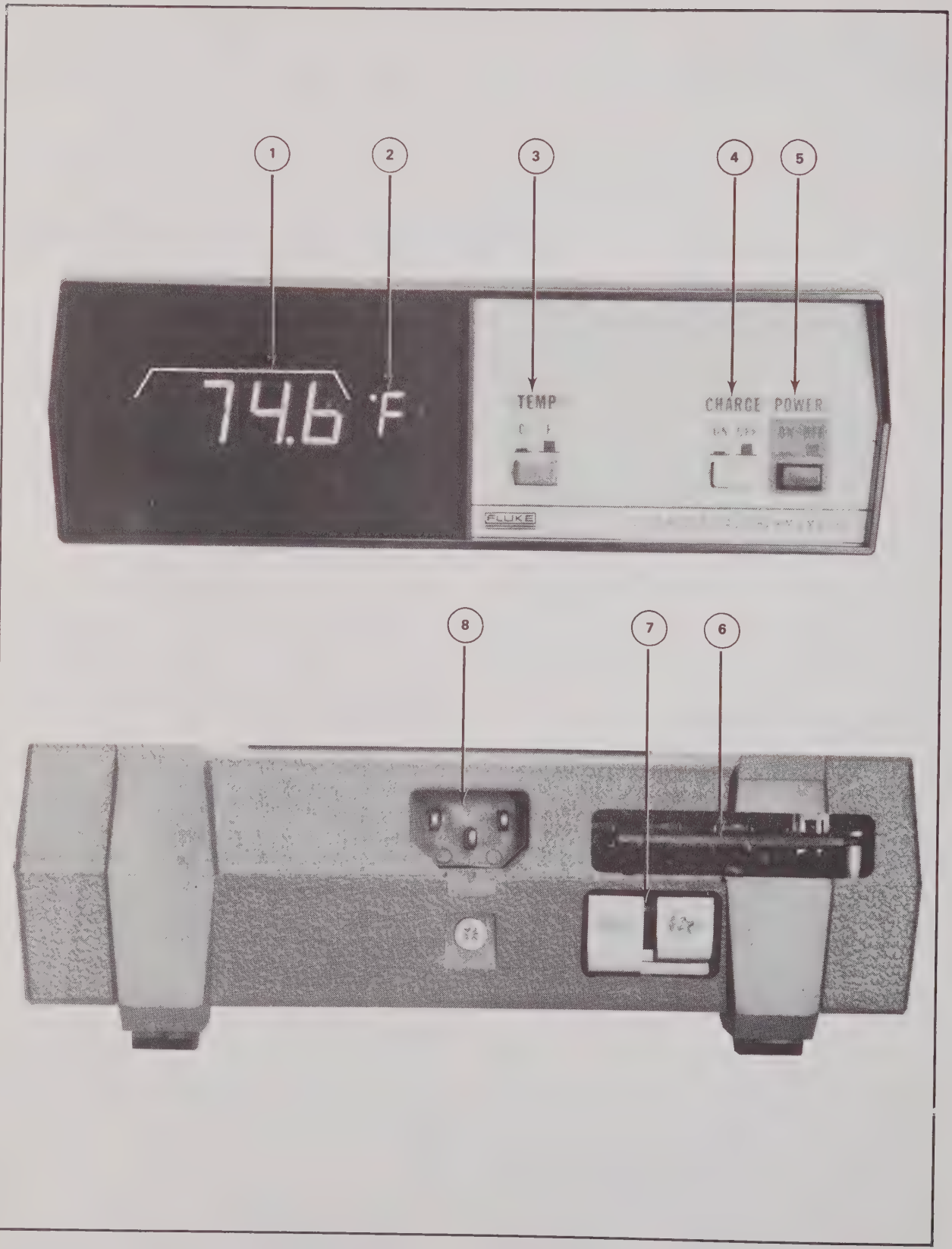


Figure 2-1. CONTROLS, INDICATORS AND CONNECTORS

Table 2-1. 2175A CONTROLS, INDICATORS AND CONNECTORS

REF. NO.	NAME	FUNCTION
1	Digital Display	Displays a four digit readout of the measured input temperature. Leading-zero suppressiong and a fixed decimal point are also included. A minus sign is displayed for negative temperature measurements. The absence of a polarity sign indicates a positive temperature measurement.
2	Temperature Sales Indicator	Displays the temperature scale represented by the digital display data; °C or °F.
3	TEMP Select Switch	Selects the temperature scale for the digital display. When the switch is depressed (IN), the °C scale is selected. The °F scale is selected when the switch is released (OUT).
4	CHARGE Switch	Selects the charge rate when the Battery Option (–01) is installed. When the switch is depressed (ON) the fast charge rate is enabled and the thermometer is not operational. The unit is operational when the CHARGE switch is released (OFF), and the batteries are charged at a trickle rate.
5	POWER Switch	Switches the 2175A on or off. The unit is turned on when the switch is depressed.
6	DOU, AOU I/O Port	Provides access to the Digital Output Unit (Option –02) or the Analog Output Unit (Option –04) input/output connector when either option is installed.
7	Thermocouple Input Connections	Provides screw-type input terminals for connecting the thermocouple to the thermometer.
8	Input Power Connector	Provides the means of connecting the instrument through the power cord to ac line power.

2-18. The ac line-input section of the 2175A power supply is fuse protected. The fuse is located on the interior of the unit near the power transformer. To access the fuse, remove the rear-panel retaining screw located beneath the ac line connector, and pull the case from the instrument. When replacement is necessary, use an AGC 1/8A fuse.

2-19. Overload and Open Thermocouple Indication

2-20. The front panel display, in addition to providing a measurement reading, is designed to serve as an overrange or open thermocouple indicator. When the measurement range of the input thermocouple is exceeded, or when the thermocouple inputs are open circuited, the display will blink. The blinking indications does not mean that the instrument is being exposed to a damaging input condition.

2-21. Thermocouple Compatibility

2-22. The 2175A is designed to operate in conjunction with a selected type of thermocouple probe. A decal on the bottom of the unit identifies the compatible thermocouple type. When necessary, the 2175A can be modified in the field to accommodate any one of the following thermocouple types: J, K, E or T. Use the following procedure to change thermocouple types:

a. Refer to Table 1-1 in Section 1 of this manual and order the type select pcb which corresponds to the desired thermocouple type. These pcbs are low-cost items and can be purchased from any one of the John Fluke Technical Service Centers (See Section 7) or from the John Fluke Mfg. Co., Inc.

b. Disconnect the 2175A from line power.

c. Remove any ribbon-cable connectors that may be attached to the rear of the 2175A.

d. Disconnect the power cord from the rear of the unit.

e. Remove the rear-panel screw located just below the power input connector.

f. Pull the 2175A front panel and pcb assembly out the front of the plastic case.

g. Unplug and remove the currently installed type select pcb from the position shown in Figure 2-2, and install the new one in its place.

NOTE

The thermocouple type is etched on the type select pcbs. When properly installed the arrows on the pcb point toward the digital display.

h. Place a piece of tape over the thermocouple type indications on the bottom-side decal, and mark the new thermocouple type on it.

i. Connect the new thermocouple type probe to the thermocouple input terminals. Observe polarity shown on bottom-side decal.

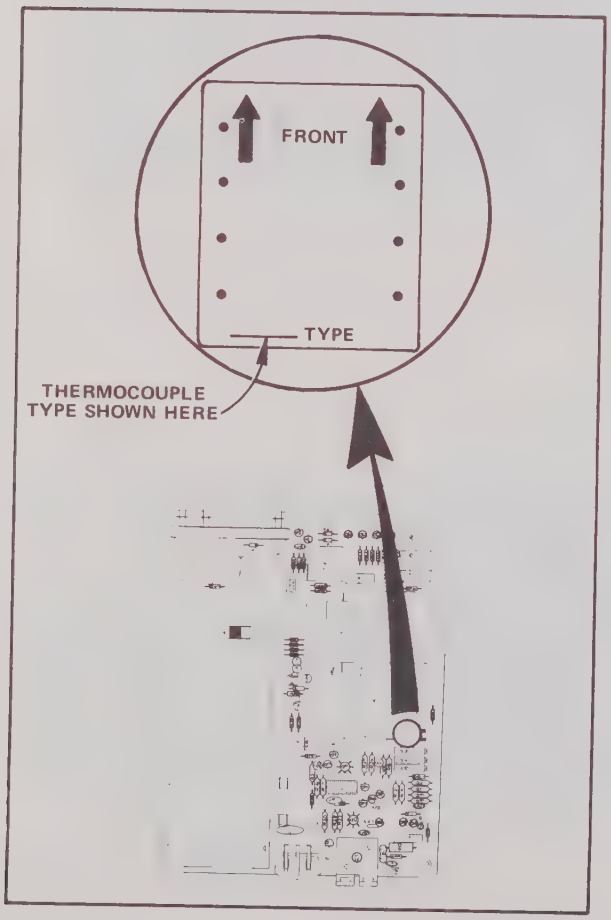


Figure 2-2. TYPE SELECT PCB, LOCATION AND INSTALLATION DETAILS

j. Connect the unit to line power, and complete the routine calibration procedure given in Section 4 (Maintenance) of this manual.

k. Install the unit in its case.

2-23. CHARGE Switch

2-24. The front panel CHARGE switch is operational only when the 2175A is equipped with the Battery Option (–01). A LINE/BATT switch on the interior of the unit is set to enable or disable the CHARGE switch function depending upon whether or not the –01 Option is installed. When the charge function is enabled (BATT) and the unit is operating from line power, depressing the CHARGE switch causes the batteries to be charged at a fast rate. The thermometer operation is disabled for the duration of the fast charge period. When the CHARGE switch is out, the thermometer is operational and the batteries are charged at a trickle rate.

2-25. OPERATION

2-26. With reference to previous paragraphs in this section, use the following procedure to operate the 2175A:

a. Refer to the bottom decal on the unit and connect a compatible thermocouple probe to the thermocouple input terminals. Observe polarity as shown on decal.

b. Connect the unit to the appropriate line power (not necessary if the unit is equipped with the Battery Option and a charged set of batteries) as defined on the bottom decal.

c. Energize the unit by depressing the POWER switch.

d. Set the CHARGE switch to the OFF position. See Section 6 for details concerning battery operation (Option –01).

e. Set the TEMP switch to the desired temperature scale, °C or °F.

f. Refer to Section 6 of this manual for instructions concerning the operation of the –02 and –04 Options.

g. Expose the thermocouple probe to a temperature within its specified range (See bottom decal). The probe temperature will be displayed on the front panel.

Section 3
Theory of Operation

3-1. INTRODUCTION

3-2. This section of the manual contains an overall functional description followed by a circuit analysis of the 2175A. Simplified circuit diagrams and timing diagrams are included, as necessary, to supplement the text. Detailed schematics are given in Section 8 of this manual.

3-3. OVERALL FUNCTIONAL DESCRIPTION

3-4. The Model 2175A Digital Thermometer, as shown in Figure 3-1, is a four-digit, thermocouple thermometer capable of resolving 0.2°C or 0.2°F over a temperature range of –99.8 to +999.8°C or –99.8 to 999.8°F. It features a cold-junction compensator (to eliminate the need for an ice-bath reference junction), dual-slope integration, LSI digital control logic (includes linearization programs for J, K, E and T type thermocouples), and a four-digit LED display.

3-5. In operation, the 2175A executes a continuous series of measurement cycles to update the temperature display. The measurement cycle is controlled entirely by an LSI digital IC, and includes three major subcycles; Auto-Zero period, Integrate period and Read period. Each subcycle controls the operation of the analog section of a dual-slope integrator which, in turn, generates a compare output to control the digital conversion performed by the LSI digital IC.

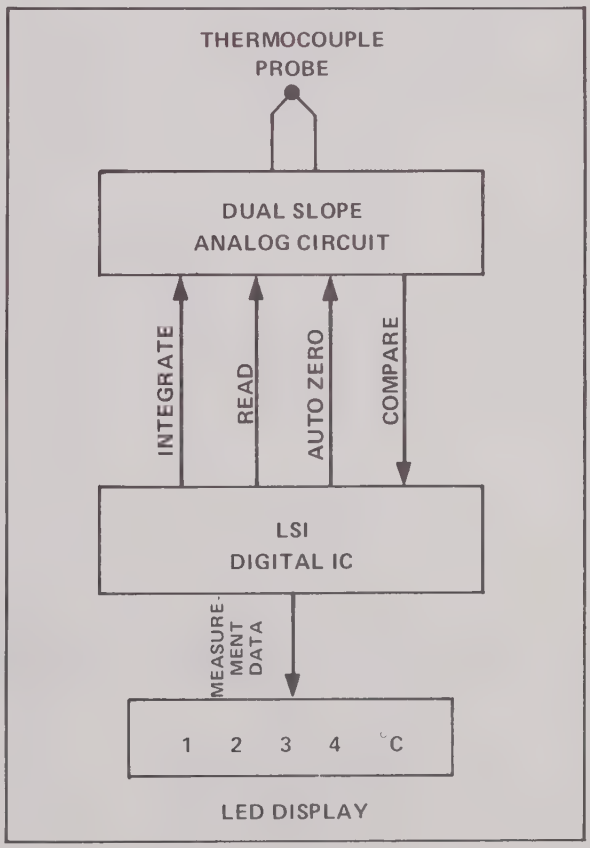


Figure 3-1. 2175A SIMPLIFIED BLOCK DIAGRAM

3-6. The configuration of the analog section of the 2175A, during each phase of the measurement cycle, is established by a combination of FET switches that are controlled by the LSI digital IC. The measurement cycle begins with the Auto-Zero period. During this period, the reference junction compensation voltage and the accumulated dc offset voltages present in the analog section are sampled and held by capacitors. These voltages are used later in the measurement cycle to cancel measurement errors introduced by offset voltages and reference junction voltage errors created at the input terminal connections. As a result, the final measurement is proportional to the thermocouple probe output voltage and does not include offset errors or reference junction voltage errors. During the Integrate period, the thermocouple input voltages (probe voltage and input terminal voltages) are applied to the integrator, and the algebraic sum of these volt-

ages is integrated over a 100 ms period. At the end of this period, the thermocouple input voltages are removed from the integrator and the Read period is started. A reference voltage is applied to the integrator during the Read period causing the integrator capacitor to be discharged at a linear rate. When the integrator output reaches zero, a compare signal is generated to end the Read period. The duration of the Read period is translated by the LSI digital IC to provide a digital indication proportional to the thermocouple probe temperature.

3-7. CIRCUIT ANALYSIS

3-8. Circuit analysis of the 2175A is discussed in two sections; digital and analog. The digital section is covered first, and particular attention is paid to the control it exercised on the analog section. The analysis of the analog section covers the analog measurement circuitry and the 2175A power supply.

3-9. Digital Section

3-10. The digital section of the 2175A consists of an LSI digital IC, a hex buffer, a seven-segment decoder/driver and an LED display. Its function is to convert the non-linear thermocouple probe voltage, as measured by the analog section, into a linear digital display. The display provides a direct reading of probe temperature in °C or °F.

3-11. The LSI digital IC contains all of the 2175A control logic and linearizing capability, and provides the hex buffer and seven-segment decoder with the data necessary to update the LED display. The linearization of the nonlinear input signal is accomplished by selecting one-of-four programs which vary the rate at which the measurement counts are accumulated. The program is selected to match a particular thermocouple type. Program selection is accomplished by a series of plug-in type select pcb's which are available as accessories.

3-12. Measurement data is continuously strobed out of the LSI digital IC in bcd, character-serial format. At the end of each measurement cycle, an update flag is raised to signify that a new reading is available. When an overload occurs, the number of accumulated counts are stored and presented, along with a blanking pulse, as output data. The blanking pulse alternately turns the display on and off to indicate the presence of an overload.

3-13. The basic measurement cycle, as shown in Figure 3-2, comprises three subcycles; a 100 ms minimum Auto-

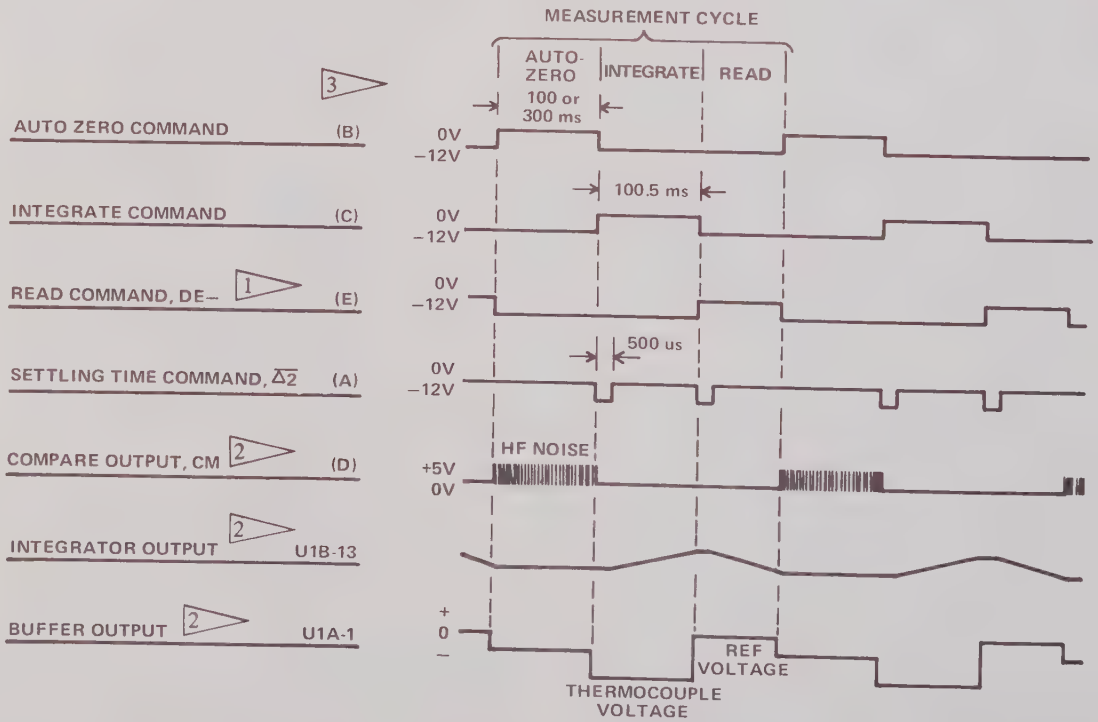


Figure 3-2. MEASUREMENT CYCLE WAVEFORMS

Zero period, a 100 ms Integrate period, and a variable Read period. The auto-zero period is extended to 300 ms when an overload occurs. To accommodate settling times in the analog section, a 500 us hold signal is inserted at the beginning and at the end of the Integrate period.

3-14. Analog Section

3-15. ANALOG MEASUREMENT CIRCUIT

3-16. The analog measurement circuit is shown in simplified form in Figure 3-3. It consists of a thermocouple input circuit, a reference-junction compensator, a voltage reference a Buffer Amplifier, an Integrator, a Comparator, and a combination of FET switches. The switches are shown in their open state and are closed by the measurement cycle commands generated by the LSI digital IC. Each switch is assigned a letter designation which corresponds to a measurement cycle command shown in Figure 3-2.

3-17. The Thermocouple Input circuit consists of an R-C filter and a pair of voltage protection diodes. The difference between the thermocouple probe voltage and the input terminal voltage is passed through the filter and appears at the arm of switch C.

3-18. The Reference-Junction Compensator consists of an isothermal block, a pair of screw type input terminals, and a transistor temperature sensor. The isothermal block maintains a known temperature differential between the input terminals and the temperature sensing transistor. Thermocouple voltages introduced by the dissimilar metals at the input terminals vary as the isothermal block adjusts to ambient temperature. Temperature changes are sensed by the forward-biased transistor which produces a correction voltage equivalent to the thermocouple voltage created at the input terminals. Predictable characteristics of a forward-biased P-N junction allow the Reference-Junction Compensator to function over a wide temperature range. The correction voltage is matched to the thermocouple probe type by a selected Offset Resistor which is supplied on a plug-in type select pcb. The correction voltage appears at the arm of switch B1.

3-19. The voltage reference consists of a resistor divider which is supplied by an accurate 6.4V dc reference voltage. The divider is calibrated to match the thermocouple probe type by a selected resistor on the plug-in type select pcb. Two voltages are available at the divider outputs; 0.5 x V ref, and 1.5 x V ref. These voltages appear at the arms of switches B2 and E, respectively.

3-20. The Buffer, Integrator and Comparator amplifiers combine to perform the analog functions of the Integrate, Read and Auto-Zero periods. The Buffer is used to provide integrator inputs during all three periods. The Integrator integrates the Buffer output voltage during the Integrate and Read periods, and functions, in combination with the Comparator, as a closed-loop amplifier during the Auto-Zero period.

3-21. During the first phase of each measurement cycle, the analog section goes through an Auto-Zero period. During this time, three auto-zero switches (B1, B2 and B3) are closed by the Auto Zero command from the LSI digital IC. Two of the switches (B1 and B2) charge the V ref capacitor to a level equal to the algebraic sum of the 0.5 x V ref output, plus the correction voltage generated by the Reference-Junc-

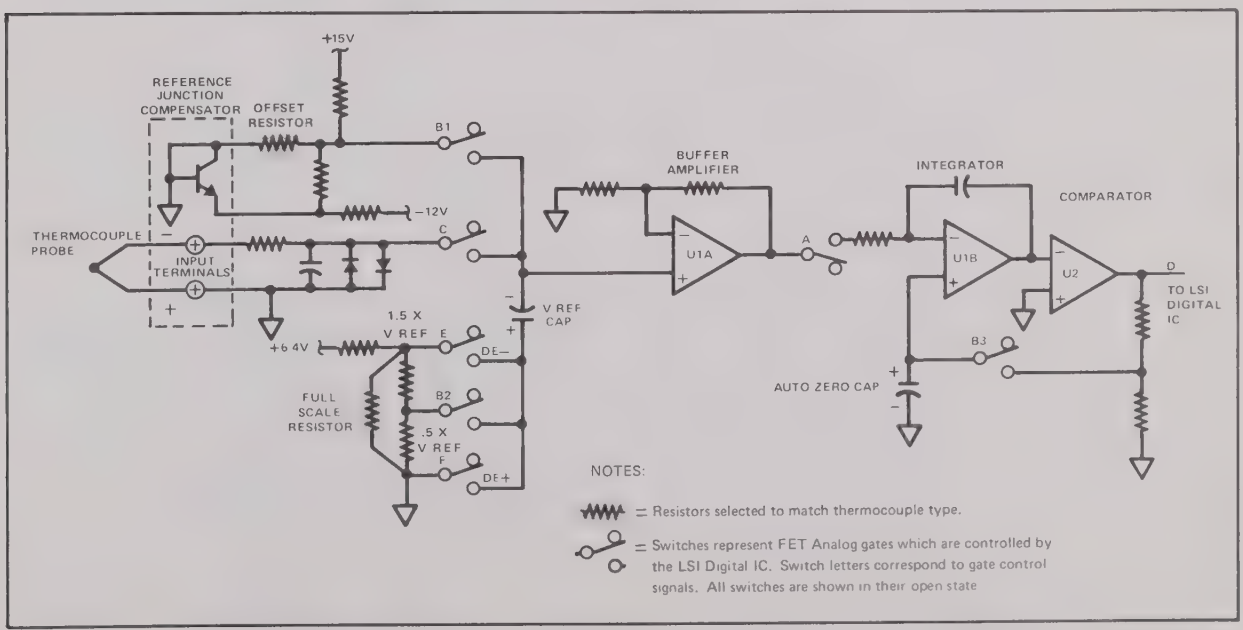


Figure 3-3. ANALOG SECTION, SIMPLIFIED CIRCUIT DIAGRAM

tion Compensator. At the same time, the correction voltage is amplified by the Buffer Amplifier and presented through switch A to the Integrator input. The third switch (B3) connects the Integrator and Comparator in a closed loop configuration and allows the Auto-Zero capacitor to charge to a value which is proportional to the Reference-Junction-Compensator correction voltage plus the offset voltages present in the Buffer, Integrator and Comparator amplifiers. At the end of the measurement cycle switches B1, B2 and B3 are opened. The V ref capacitor and the Auto-Zero capacitor retain their charge for use later in the measurement cycle.

3-22. The Integrate period starts on the leading edge of the Integrate Command from the LSI digital IC; switch A is open and switch C is closed. The thermocouple input voltage is applied through switch C to the Buffer input. After a 500 us settling period, switch A closes and the Buffer output voltage is applied to the Integrator input for 100 ms. As the integrator capacitor charges, the Integrator drives the Comparator output to either 0 or +5V dc to indicate the polarity of the thermocouple input voltage, positive or negative, respectively. The comparator output is sent to the LSI digital IC for use during the Read period. At the end of the Integrate period, the integrator capacitor is charged to a level and polarity that is proportional to the thermocouple probe voltage and switch C returns to its open state.

3-23. The Read period starts at the end of the Integrate period and one-of-two Read Modes is enabled depending upon the input polarity sensed by the comparator during the Integrate period. If a positive input is sensed, a DE– Read Mode is enabled. Similarly a DE+ Read Mode is enabled when a negative input is sensed.

3-24. If the DE– Read Mode is commanded, switch A is opened and E is closed. Switch E applies a 1.5 x V ref input to the positive side of the V ref capacitor. This voltage is algebraicly added to the voltage stored in the V ref capacitor during the previous Auto-Zero period (0.5 x V ref + Reference-Junction-Compensator voltage). As a result, the input to the Buffer Amplifier is a positive voltage equal to V ref plus the Reference Junction-Compensator voltage.

3-25. If the DE+ Read Mode is commanded, switch A is opened and F is closed. Switch F grounds the positive side of the V ref capacitor and causes the Buffer amplifier input to be driven to the voltage stored in the V ref capacitor during the previous Auto-Zero period (0.5 x V ref + Reference-Junction Compensator voltage). As a result, the input to the Buffer Amplifier is a negative voltage equal to 0.5 x V ref plus the Reference-Junction-Compensator voltage.

3-26. After a 500 us settling time, switch A closes and the Buffer output voltage is applied to the Integrator input. This causes the integrator capacitor to discharge at a linear rate determined by the reference voltage. The discharge continues until the integrator output voltage reaches zero volts. the level existing prior to the integrate period. This level is sensed by the Comparator which signals the LSI digital IC to terminate the A/D conversion of measurement data.

3-27. Offset voltages present during the Integrate and Read periods are cancelled out by offset voltages that were sampled and held during the Auto-Zero period. However, the Reference-Junction-Compensator voltage (also sampled and held during Auto Zero) is added to the integrator voltage during the Integrate period. As a result, the displayed temperature is equal to the thermocouple probe temperature.

3-28. POWER SUPPLY

3-29. The 2175A power supply consists of a power transformer, fuse, power input connector, a dc-to-dc converter, battery holders, and associated regulating and charging circuits. The function of the power supply is to provide the unit with the necessary operating voltages during both battery and line operation, and to provide a means of recharging the Ni-Cad batteries, when installed. Operating voltages include: +5, +7.5, +15 and –12V dc, and 5V ac (rms). All voltages except the +5V dc and the 5V ac are regulated.

NOTE

The 5V ac output is used to power the –02 and –04 options. Since this voltage is not generated during battery operation, the –02 and –04 options are only operational when the 2175A is operated from line power.

3-30. The dc-to-dc converter is energized by a +5V dc input which is derived from either the power transformer during line operation, or the rechargeable batteries during battery operation. Conventional regulating techniques produce +7.5, +15 and –12V dc operating voltages at the dc-to-dc converter output.

3-31. When batteries are installed in the 2175A, an internal Line/Battery switch is set to BATT to enable the front panel CHARGE switch. During line operation, the CHARGE switch provides for the selection of either fast (ON) or slow (OFF) battery charge rates. The unit is operative during slow-charge. However, during fast-charge the numeric display is blanked and the °C temperature scale character is lit. Lamp DSI operates as a ballast in the fast charge mode.

Section 4
Maintenance

WARNING!

THESE SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRIC SHOCK, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN THE OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.

4-1. INTRODUCTION

4-2. This section of the manual contains maintenance information for the Model 2175A Digital Thermometer. This includes service information, general maintenance, a performance test and calibration. The performance test is recommended as an acceptance test when the instrument is first received, and later as a preventive maintenance tool to verify specifications after repair. A calibration cycle of one year is recommended to maintain the unit within the one-year specifications. If the 90-day specifications are to be maintained a 90-day calibration cycle is recommended. Table 4-1 lists the equipment required for both the performance test and calibration. If the recommended model is not available, a substitute that meets the minimum use specifications may be used.

Table 4-1. TEST EQUIPMENT REQUIREMENTS

INSTRUMENT TYPE	MINIMUM USE SPECIFICATIONS	RECOMMENDED MODEL
Thermocouple Probes	Type J, K, T or E (select type compatible with thermometer)	Omega TJ36 Series, Grounded Sheath
Mercury Thermometer	0.02°C Resolution	Printco Model ASTM-56C
Dewar Flask and Cap	1-pint capacity	Thermos Bottle
DC Voltage Calibrator	Output Voltage: 0 to 100V Accuracy: 0.002% Resolution: 10 uV	Fluke Model 343A
Variable Line-Voltage Transformer	100, 115 or 230 V ac ±10%, as required	Variac
Resistors	100Ω ±.005% 1/8W, TC ±1ppm 9900Ω ±.005% 1/8W, TC ±1ppm	Dale Type WWA

4-3. SERVICE INFORMATION

4-4. The 2175A is warranted for a period of one year upon delivery to the original purchaser. The WARRANTY is located on the back of the title page located in the front of this manual.

4-5. Factory Authorized calibration and service for each Fluke product is available at various world-wide locations. A complete list of these service centers is included in Section 7 of this manual. If requested, an estimate will be provided to the customer before any work is begun on instruments that are beyond the warranty period.

4-6. GENERAL MAINTENANCE

4-7. Access Information

4-8. Use the following procedure to gain access to the interior of the 2175A:

a. Set the POWER switch to off and disconnect the ac power cord from the unit.

b. Disconnect the thermocouple probe at the input terminals.

c. Remove the phillips-head screw located in the center of the rear panel.

d. Pull the instrument out the front of the case.

4-9. Cleaning

4-10. Clean the 2175A periodically to remove dust, grease and other contamination. Use the following procedure:

CAUTION!

Do not use aromatic hydrocarbons or chlorinated solvents to clean the 2175A. They will react with the plastic materials used in the instrument.

a. Clean the front panel and case with a soft cloth dampened with a mild solution of detergent and water.

b. Clean the surface of the pcb using clean dry air at low pressure (≤ 20 psi). If grease is encountered, spray with Freon T.F. Degreaser and remove grime with clean dry air at low pressure.

4-11. Fuse Replacement

WARNING!

DISCONNECT THE UNIT FROM LINE POWER BEFORE ATTEMPTING FUSE REPLACEMENT.

4-12. The input power fuse is located on the interior of the unit near the power transformer. If replacement is necessary, use an AGC 1/8A fuse.

4-13. Service Tools

4-14. No special tools are required to maintain or repair the 2175A.

4-15. PERFORMANCE TEST

4-16. The performance test, as outlined in Table 4-2, is used to compare the 2175A performance with the list of specifications given in Table 1-3. These tests are suitable for incomming inspection, periodic maintenance and to verify specifications. A Performance Test Checklist is provided at the end of this section. If the instrument fails to meet any of its specifications, repair or calibration is required.

NOTE

The performance test should be conducted at an ambient temperature of 25 ±2°C.

4-17. Initial Procedure

4-18. Complete the following procedure prior to executing the performance test:

a. Connect a variable line-power transformer to line power and adjust the output to the nominal line voltage at which the 2175A is designed to operate; 100, 115 or 230V ac.

b. Connect a power cord between the transformer output and the 2175A power input connector.

c. Set the 2175A front panel controls as follows:

1. POWER switch to ON.
2. TEMP switch to °F or °C.
3. CHARGE switch to OFF.

d. Prepare a 32°F ice-point bath using a thermos bottle and a mercury thermometer.

e. Complete the equipment connections shown in Figure 4-1.

NOTE

The thermocouple probe type must be compatible with the 2175A under test.

f. Set the calibrator for a 0V dc output and select the 10 V range.

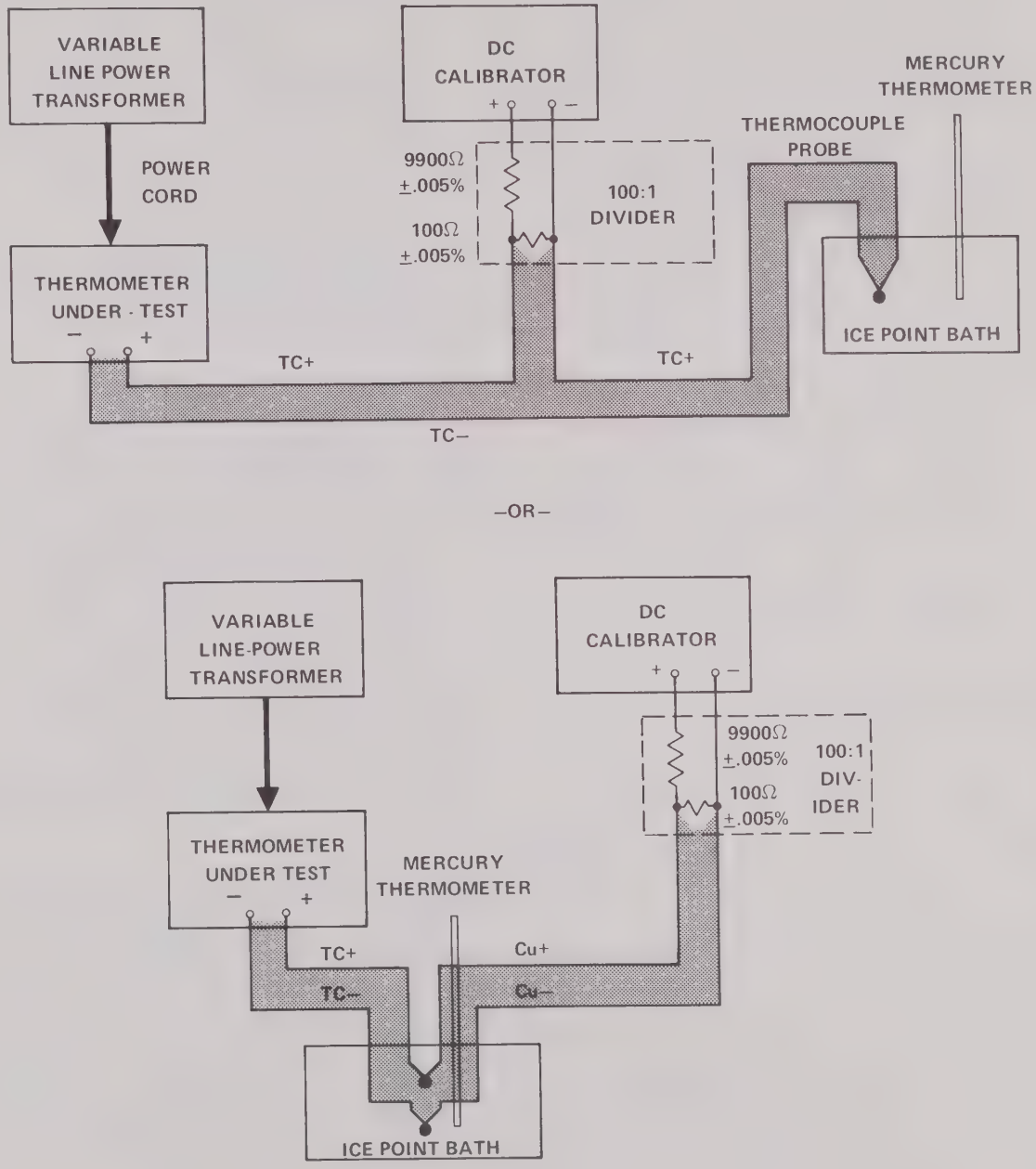
g. Energize the calibrator.

Table 4-2. PERFORMANCE TEST DESCRIPTION

TEST INSTRUMENT PARAMETERS	PERFORMANCE SPECIFICATIONS	TEST METHOD
Line Voltage Regulation	Satisfactory Performance with any line voltage within ±10% of nominal; 100, 115 or 230V ac	The display is monitored during the accuracy test as the line voltage is varied.
Accuracy Test	Temperature Accuracy as stated in Table 2 of 1-3. (Table 1 specifications are ensured when Table 2 specifications are verified.)	Known input voltages are substituted for the thermocouple inputs. Cardinal-point checks ensure accuracy over the entire temperature range.
Overload and Open Input Test	The display flashes to indicate both over range input voltages and open input terminals.	An over range voltage is applied to the thermocouple input terminals, and the input terminals are open circuited.
Internal Temperature Rise	<8°C above ambient	The thermocouple input terminals are shorted and the temperature of the reference junction is displayed.

4-19. Line Voltage Regulation

4-20. Line voltage regulation is tested in conjunction with the accuracy test given in the following paragraph. As the accuracy test is executed, vary the line voltage ±10% with a



NOTES:

1. = Thermocouple wire
2. If the thermometer is designed to operate with a type B thermocouple, the thermocouple probe(s) and ice bath can be deleted from the test set-up. Connect the divider output directly to the thermometer inputs using copper wire.

Figure 4-1. PERFORMANCE–TEST EQUIPMENT CONNECTIONS

variable line-power transformer to ensure proper operation within the line-voltage limits.

4-21. Accuracy Test

4-22. Use the following procedure to test the 90-day or one-year accuracy of the 2175A:

NOTE

Periodically agitate the ice-point bath to ensure its accuracy and to decrease the possibility of temperature gradients between the mercury thermometer and the thermocouple probe.

NOTE

Optimum accuracy is ensured by checking the unit on the °F temperature scale. However, for convenience, both the °F and °C accuracy measurements are given in Table 4-3.

a. Refer to Table 4-3 and select the group of figures that correspond to the thermocouple type used with the 2175A.

b. Sequentially, set the calibrator to obtain each of the divider output voltages listed within the selected group, and check the thermometer display against the appropriate display limits; 90-day or 1-year.

4-23. Overload and Open Input

4-24. Use the following procedure to test the 2175A's overload and open-circuit detectors:

a. Set the calibrator output to 10 V dc. The thermometer display should begin to flash. While the display is lit, it should read the high end of the temperature range assigned to the compatible thermocouple type:

J	=	999.8°F	or	777.8°C
K	=	999.8°F	or	999.8°C
T	=	752.0°F	or	400.0°C
E	=	999.8°F	or	999.8°C

b. Set the calibrator output to 0V dc.

c. Remove the input connections at the thermometers thermocouple input terminals. The display should begin to flash and read the high end of the temperature range as described in step a of this procedure.

4-25. Internal Temperature Rise

4-26. Use the following procedure to measure the thermometer's internal temperature as sensed by the reference junction:

NOTE

This procedure assumes that the thermometer has been energized for at least 30 minutes and allowed to stabilize at an ambient temperature of 25 ±2°C.

a. Monitor the ambient temperature (room temperature) using a mercury thermometer.

b. Connect a copper wire between the 2175A's thermocouple input terminals. The unit will display

Table 4-3. TEMPERATURE ACCURACY

TYPE	DIVIDER OUTPUT (mV dc)	°F DISPLAY LIMITS 90 DAY	°F DISPLAY LIMITS 1 YEAR	DIVIDER OUTPUT (mV dc)	°C DISPLAY LIMITS 90 DAY	°C DISPLAY LIMITS 1 YEAR
J	29.263	990.8 to 993.2	990.4 to 993.6	42.640	754.9 to 756.3	754.5 to 756.7
	2.288	110.8 to 113.2	110.4 to 113.6	2.288	43.7 to 45.1	43.3 to 45.5
	−1.643	−29.6 to −26.4	−30.1 to −25.9	−2.175	−45.4 to −43.4	−45.6 to −43.2
	−3.198	−89.6 to −86.4	−90.1 to −85.9	−3.686	−78.8 to −76.8	−79 to −76.6
K	22.059	990.6 to 993.4	990.2 to 993.8	40.404	976.7 to 978.9	976.4 to 979.2
	2.709	150.6 to 153.4	150.2 to 153.8	0.884	21.1 to 23.3	20.8 to 23.6
	−1.691	−50 to −46	−50.6 to −45.4	−1.691	−45.6 to −43.2	−45.9 to −42.9
	−2.475	−90 to −86	−90.6 to −85.4	−2.848	−79 to −76.6	−79.3 to −76.3
T	20.188	731 to 733	730.5 to 733.5	19.497	377.2 to 378.4	376.9 to 378.7
	0.879	71 to 73	70.5 to 73.5	0.879	21.6 to 22.8	21.3 to 23.1
	−1.240	−29.7 to −26.3	−30.9 to −25.1	−2.009	−56.6 to −54.6	−57.2 to −54
	−2.370	−89.7 to −86.3	−90.9 to −85.1	−2.720	−78.8 to −76.8	−79.4 to −76.2
E	39.694	990.7 to 993.3	990.2 to 993.8	74.694	976.8 to 978.8	976.4 to 979.2
	2.694	110.7 to 113.3	110.2 to 113.8	2.694	43.4 to 45.5	43 to 45.8
	−1.897	−29.7 to −26.3	−31 to −25	−3.000	−56.6 to −54.6	−57.3 to −53.9
	−3.641	−89.7 to −86.3	−91 to −85	−4.196	−78.8 to −76.8	−79.5 to −76.1

the temperature of the internal reference junction. This temperature should not exceed the ambient temperature by more than 8°C.

c. Remove the short from the thermocouple input terminals and disconnect the unit from the power transformer.

4-27. CALIBRATION

4-28. The 2175A should be calibrated once a year or every 90 days, as required to maintain the desired accuracy. Calibration should also be performed after the unit has been repaired and after the thermocouple type select pcb has been changed.

4-29. Routine calibration (periodic calibration or when a type select pcb is changed) may be accomplished using either one-of-two calibration methods. The recommended method (and the most accurate) is a voltage calibration technique utilizing a single temperature point. The second method is the traditional ice-point-reference technique as outlined earlier in this section under Performance Test.

4-30. If the ice-point-reference method is used, complete the set-up procedure for the performance test, as given earlier in this section. Then adjust the Offset Pot (see Figure 4-2) to obtain a display equal to the ice-point reference, 0°C or 32°F. Finally, set the calibrator output to obtain the appropriate divider output voltage, as given in Table 4-4, and adjust the Full Scale Cal pot to obtain the corresponding display reading.

4-31. The voltage calibration method, as given in the following procedure, is recommended for both routine calibration and calibration after repair. The procedure allows the unit to be calibrated on either the °C or °F scale (Calibrating either scale ensures the accuracy of both scales). Interpolation of the least significant digit is necessary when calibrating the unit. However, calibrating on the °F scale requires interpolation of ±½ a digit, where as, calibrating on the °C scale requires interpolation of ±¼ of a digit. The accuracy of either or both scales can be verified after calibration by executing the performance test given earlier in this section.

NOTE

For routine calibration, skip the shaded steps in the following procedure. For calibration after repair, perform both the shaded and unshaded steps.

a. Remove the 2175A from its case.

NOTE

For B type thermocouples skip steb b. The RJD switch should remain in the operate position.

Table 4-4. FULL SCALE CALIBRATION

PROBE TYPE	°F		°C	
	DIVIDER OUTPUT (mV dc)	DISPLAY READING	DIVIDER OUTPUT (mV dc)	DISPLAY READING
J	+29.263	992.0°F	42.640	755.6°C
K	+22.059	992.0°F	40.404	977.8°C
T	+20.188	732.0°F	19.497	377.8°C
E	+39.694	992.0°F	74.694	977.8°C

b. Locate the RJD switch on the main pcb assembly (See Figure 4-2) and set it to the RJD position.

c. Set the front panel TEMP switch to the desired temperature scale (°C or °F). Either scale may be used for calibration.

d. Complete the equipment connections shown in Figure 4-1.

1. Set dc voltage calibrator to: 10V range, 0V output.

2. Construct 100:1 divider using resistors specified in Table 4-1.

e. Connect the voltage divider output to the 2175A thermocouple input terminals (match polarities).

f. Connect the digital thermometer to the appropriate line voltage and energize the unit.

g. Adjust C18, as necessary, to obtain a flashing minus sign(–) on the thermometer display.

h. Determine the thermocouple type that is compatible with the thermometer. See decal on bottom of case or check markings on plug-in Thermocouple Type PCB as shown in Figure 4-2.

i. Refer to Table 4-4 and set the calibrator output to obtain the voltage divider output specified for the compatible thermocouple type.

j. Adjust the Full-Scale pot (R6) to obtain the temperature display specified in Table 4-4.

k. Set the RJD switch to the operate position.

l. Remove the divider leads from the thermocouple input terminals.

NOTE

This completes the calibration procedure for units compatible with B type thermocouples.

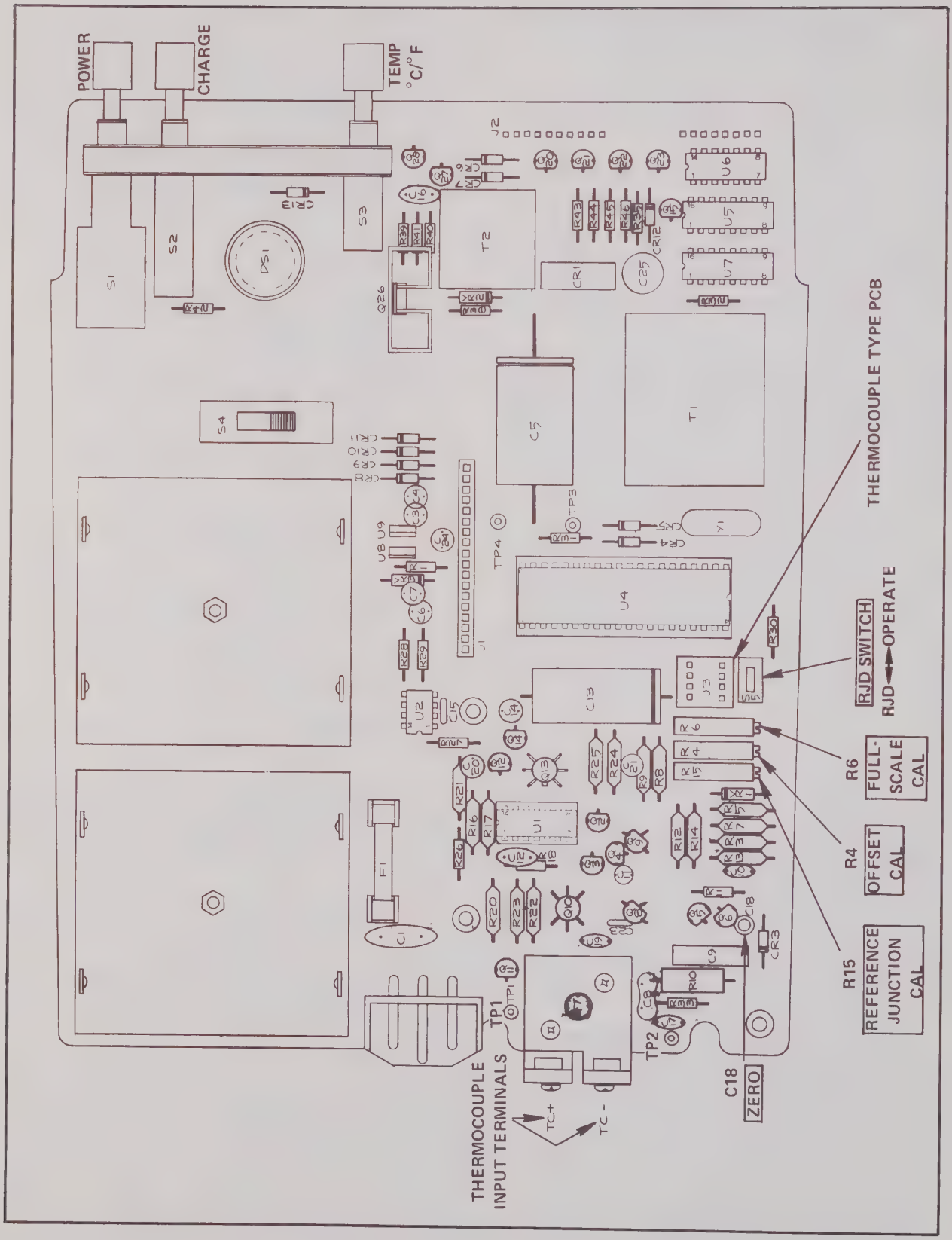


Figure 4-2. TEST POINT AND ADJUSTMENT LOCATIONS

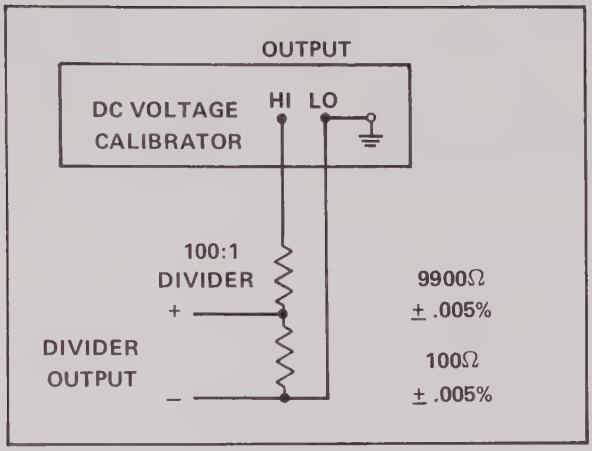


Figure 4-3. EQUIPMENT CONNECTIONS

m. Short the thermocouple input terminals using a small piece of hook-up wire.

n. Select the 100V range on the calibrator and set the calibrator output to 57.8500V dc.

CAUTION!

Make sure the voltage divider output is 578.5mV before going to the next step.

o. Connect the voltage divider output to TP1 (+) and TP2 (–) as shown in Figure 4-2.

p. Adjust the OFFSET CAL pot (R4) for a temperature display of 77°F or 25°C.

q. Remove the short at the thermocouple input terminals.

r. Connect the compatible type of thermocouple probe to the thermocouple inputs (observe polarity).

s. Place the thermocouple probe in a room-temperature lag bath. Use an accurate mercury thermometer to monitor the temperature of the bath.

t. Adjust the Reference Junction Cal pot (R15) to obtain a display reading that agrees with the lag-bath temperature. Use LSD flicker for interpolation.

NOTE

If the shaded steps of this procedure have been performed, skip step u.

u. Adjust the OFFSET CAL pot (R4) to obtain a display reading that agrees with the lag-bath temperature.

v. Recheck and, if necessary, reset the full scale adjustment by repeating steps b, d, e, h, i, j and k of this procedure.

w. Disconnect the thermocouple from the input terminals and reassemble the 2175A.

4-32. TROUBLESHOOTING

4-33. A troubleshooting guide for the 21 A is given in Table 4-5. The guide is in the form of a tabular flow chart and is recommended for use in isolating a problem to a functional circuit group. Details necessary to troubleshoot a fault in a functional circuit group can be derived from Section 3, Theory of Operation, and Section 8, Schematic Diagrams.

Table 4-5. TROUBLESHOOTING GUIDE

STEP	INSTRUCTION	YES	NO	GO TO
1	Energize the unit and connect a short across the thermocouple input terminals.			2
2	Does the display light?	16	3	
3	Is the power fuse blown?	4	5	
4	Replace fuse.			2
5	Are all power supply voltages present; +5, +7.5, +15 and −12V dc?	7	6	
6	Repair power supply.			2
7	Are Strobe Out pulses present at pins 9, 10, 11 and 12 of U4. (Use logic common as reference.)?	10	8	
8	Is crystal operating?	10	9	
9	Replace crystal.			2
10	Are display drivers functioning?	13	11	
11	Is output data present at pins 4, 5, 6 and 7 of U4?	12	13	
12	Replace display drivers as necessary.			2
13	Are $\overline{\wedge}$2, A2, INT, DE+ or DE−, and CM present at U4?	14	15	
14	Display PCB defective. Repair as necessary.			2
15	U4 is defective. Replace.			2
16	Does display read approximate ambient temperature?	21	17	
17	Refer to Section 3 of this manual and use a scope to check for the presence of the waveforms shown in Figure 3-2.			18
18	Are all waveforms correct?	20	19	
19	Perform the necessary repairs to the analog circuit.			17
20	Calibrate the thermometer.			21
21	End. Thermometer is functional.			

PERFORMANCE TEST CHECKLIST

Fluke Model 2175A Digital Thermometer

Serial No. _____
Tested By _____
Date _____

Line Voltage Regulation . . . . . Passed ( ) Failed ( )

Accuracy Test . . . . . See Verification Tables

°F VERIFICATION TABLE

PROBE TYPE	NOMINAL TEMPERATURE °F	90 DAY			1 YEAR		
		MIN.	ACTUAL	MAX.	MIN.	ACTUAL	MAX.
J	992	990.8		993.2	990.4		993.6
	112	110.8		113.2	110.4		113.6
	–28	–29.6		–26.4	–30.1		–25.9
	–88	–89.6		–86.4	–90.1		–85.9
K	999	990.6		993.4	990.2		993.8
	152	150.6		153.4	150.2		153.8
	–48	–50		–46	–50.6		–45.4
	–88	–90		–86	–90.6		–85.4
T	732	731		733	730.5		733.5
	72	71		73	70.5		73.5
	–28	–29.7		–26.3	–30.9		–25.1
	–88	–89.7		–86.3	–90.9		–85.1
E	992	990.7		993.3	990.2		993.8
	112	110.7		113.3	110.2		113.8
	–28	–29.7		–26.3	–31		–25
	–88	–89.7		–86.3	–91		–85

°C VERIFICATION TABLE

PROBE TYPE	NOMINAL TEMPERATURE °C	90 DAY			1 YEAR		
		MIN.	ACTUAL	MAX.	MIN.	ACTUAL	MAX.
J	755.6	754.9		756.3	754.5		756.7
	44.4	43.7		45.1	43.3		45.5
	–44.4	–45.4		–43.4	–45.6		–43.2
	–77.8	–78.8		–76.8	–79		–76.6
K	977.8	976.7		978.9	976.4		979.2
	22.2	21.1		23.3	20.8		23.6
	–44.4	–45.6		–43.2	–45.9		–42.9
	–77.8	–79		–76.6	–79.3		–76.3
T	377.8	377.2		378.4	376.9		378.7
	22.2	21.6		22.8	21.3		23.1
	–55.6	–56.6		–54.6	–57.2		–54
	–77.8	–78.8		–76.8	–79.4		–76.2
E	977.8	976.8		978.8	976.4		979.2
	44.4	43.4		45.5	43		45.8
	–55.6	–56.6		–54.6	–57.3		–53.9
	–77.8	–78.8		–76.8	–79.5		–76.1

Overload

Overrange . . . . . Passed ( ) Failed ( )

Open Circuit . . . . . Passed ( ) Failed ( )

Internal Temperature Rise . . . . . < 8°C above ambient

Section 5

Lists of Replaceable Parts

REFERENCE DESIGNATOR	ASSEMBLY NAME/NUMBER	PART NO.	PAGE
	Digital Thermometer, Final Assembly (2175A)	———	5-3
A1	Thermometer Assembly		
	100V (2175A-4001T-2)	434886	5-4
	115V (2175A-4001T)	425850	5-4
	230V (2175A-4001T)	425850	5-4
A1A1	Thermometer PCB Assembly (2175A-4001)	421214	5-5
A2	Display PCB Assembly (2165A-4002T)	421189	5-9
A3	Type Select PCB Assembly	———	5-10

5-1. INTRODUCTION

5-2. This section contains an illustrated parts breakdown of the instrument. Components are listed alpha-numerically by assembly. Electrical components are listed by reference designation and mechanical components are listed by item number. Each listed part is shown in an accompanying illustration.

5-3. Parts lists include the following information:

a. Reference Designation or Item Number.

b. Description of each part.

c. Fluke Stock Number.

d. Federal Supply Code for Manufacturers. (See Appendix A for Code-to-Name list.)

e. Manufacturer's part Number or Type.

f. Total Quantity per assembly or component.

g. Recommended Quantity: This entry indicates the recommended number of spare parts necessary to support one to five instruments for a period of two years. This list presumes an availability of common electronic parts at the maintenance site. For maintenance for one year or more at an isolated site, it is recommended that at least one of each assembly in the instrument be stocked. In the case of optional subassemblies, plug-ins, etc. that are not always part of the instrument, or are deviations from the basic instrument mode, the REC QTY column lists the recommended quantity of the item in that particular assembly.

h. Use Code is provided to identify certain parts that have been added, deleted or modified during production of the instrument. Each part for which a use code has been assigned may be identified with a particular instrument serial number by consulting the Use Code Effectivity, paragraph 5-7.

5-4. HOW TO OBTAIN PARTS

5-5. Components may be ordered directly from the manufacturer by using the manufacturer's part number, or from the John Fluke Mfg. Co., Inc. factory or authorized representative by using the FLUKE STOCK NUMBER. In the event the part you order has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions, if necessary.

5-6. To ensure prompt and efficient handling of your order, include the following information.

a. Quantity

b. FLUKE Stock Number

c. Description

d. Reference Designation or Item Number

e. Printed Circuit Board Part Number

f. Instrument model and Serial number

5-7. USE CODE EFFECTIVITY LIST

USE CODE	SERIAL NUMBER EFFECTIVITY

FINAL ASSEMBLY 2175A

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
	DIGITAL THERMOMETER FINAL ASSEMBLY, 2175A						
A1	Thermometer Assembly				1		
	100V ac (2175A-4001T-2)	434886	89536	434886			
	115V ac (2175A-4001T)	425850	89536	425850			
	230V ac (2175A-4001T)	425850	89536	425850			
A2	Display PCB Assembly (2165A-4002)	421198	89536	421198	1		
A3	Type Select PCB Assembly				1		
	One-of-four possible type select pcb assemblies is supplied with the unit.						
	J Type Select PCB Assembly (2160A-4016)	415653	89536	415653			
	K Type Select PCB Assembly (2160A-4017)	415661	89536	415661			
	T Type Select PCB Assembly (2160A-4018)	415927	89536	415927			
	E Type Select PCB Assembly (2160A-4019)	415935	89536	415935			
1	Adhesive	436766	89536	436766	1		
2	Case, molded plastic	427997	89536	427997	1		
3	Cord, ac line				1	1	
	100 or 115V ac	343723	89536	343723			
	230V ac	343780	89536	343780			
4	Decal, case bottom	419127	89536	419127	1		
5	Decal, front panel	419119	89536	419119	1		
6	Decal, handle	347401	89536	347401			
7	Feet, rubber	338632	89536	338632	2		
8	Handle, molded plastic	330092	89536	330092	1		
9	Lens, plastic	419085	89536	419085	1		
10	Panel, front	417485	89536	417485	1		
11	Retainer, neoprene	352484	89536	382484	2		
12	Shield	438440	89536	438440	1		
13	Washer, handle	340505	89536	340505	2		

A1 THERMOMETER ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
A1	**THERMOMETER ASSEMBLY**				REF		
	100V ac (2175A-4001T-2)	434886	89536	434886			
	115V ac (2175A-4001T)	425850	89536	425850			
	230V ac (2175A-4001T)	425850	89536	425850			
A1A1	Thermometer PCB Assembly (2175A-4001)	421214	89536	421214	1		
T1	Transformer, power				1		
	100V ac (2165A-6550)	437640	89536	437640			
	115V ac (2165A-6510)	437632	89536	437632			
	230V ac (2165A-6510)	437632	89536	437632			
U4	IC, LSI digital	393777	89536	393777	1	1	

A1A1 THERMOMETER PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
A1A1	**THERMOMETER PCB ASSEMBLY (2175A-4001)**	421214	89536	421214	REF		
	Figure 8-1						
C1	Cap, cer, .01 uF ±20%, 3kV	266320	56289	41C301A2	1		
C3,C4	Cap, Ta, 6.8 uF ±20%, 35V	363713	56289	196D685X0035 KA1	2		
C5	Cap, elect, 4000 uF +100/−10%, 10V	330761	25088	B41010-4700/10	1	1	
C6,C7, C14, C20, C21, C24	Cap, Ta, 10 uF ±20%, 20V	330662	56289	196D106X0020 JA1	6		
C8	Cap, mica, 100 pF ±1%, 500V	226126	71234	DM15F100F	1		
C9	Cap, mylar, 0.47 uF ±10%, 100V	369124	73445	C280MA/HA47 0K	1		
C10	Cap, disc, 100 pF ±10%, 1kV	105593	71590	DD101	1		
C11	Cap, Ta, 2.2 uF ±10%, 15V	364216	56289	196D222X9015 HA1	1		
C12	Cap, cer, .025 uF ±20%, 100V	168435	56289	C023B101H253 M	1		
C13	Cap, polypro, 0.47 uF ±10%, 50V	363085	89536	363085	1		
C15	Cap, cer, 2700 pF ±20%, 100V	362889	72982	8121-A100-W5R 272M	1		
C16	Cap, cer, .0012 uF ±10%, 500V	106732	71590	CF122	1		
C17, C19	Cap, cer, 1000pF ±10%, 500V	357806	56289	C106B102G102 K	2		
C18	Cap, var, .25 - 1.5 pF, 2kV	218206	72982	530-000	1	1	
C23	Cap, cer, 1 pF, ±0.25 pF, 100V	436477	72982	8101-A100-C0G 109G	1		
C25	Cap, elect, 100 uF −10/+100%, 25V	416982	89536	416982	1	1	
CR1	Diode, bridge rectifier	392910	89536	392910	1	1	
CR3 thru CR11	Diode, Si, 150 mA, 75V	203323	09214	1N4148	9	2	

A1A1 THERMOMETER PCB ASSEMBLY (Cont.)

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
CR12, CR13	Diode, Si, Rectifier	348491	04713	1N4002	2	1	
DS1	Lamp	352237	00779	85863-3	1	1	
F1	Fuse, fast-blo, 1/16A	109348	71400	AGC1-16	1	5	
J1	Connector, female, 18-pin	435024	00779	583773-8	1		
Q2 thru Q6,Q8, Q9, Q12, Q14	Xstr, J-FET, N-channel	343830	32293	ITS30168	9	2	
Q7	Xstr, Si, NPN	329698	07263	2N2484	1	1	
Q10	Xstr, FET, dual N-channel	439703	89536	439703	1	1	
Q11, Q15	Xstr, Si, NPN	218396	04713	2N3904	1	1	
Q13	Xstr, FET, dual N-channel	379321	17856	E7024	1	1	
Q20 thru Q23	Xstr, Si, NPN	381798	04713	MPS-A-13	4	1	
Q26	Xstr, Si, NPN	418459	01295	T1P-31	1	1	
Q27, Q28	Xstr, Si, NPN	272237	07263	2N4946	2	1	
R1	Res, comp, 430 ±5%, ¼W	203869	01121	CB4315	1		
R3	Res, mf, 15.8k ±1%, 1/8W	293688	91637	MFF1-81582F	1		
R4	Res, var, 25k ±20%, ½W	285213	71450	190PC253B	1	1	
R5	Res, mf, 261k ±1%, 1/8W	257535	91637	MFF1-82613F	1		
R6	Res, var, 10k ±20%, ½W	267880	71450	190PC103B	1	1	
R7	Res, mf, 195k ±0.1%, 1/8W	436485	91637	MFF1-81953B	1		
R8	Res, mf, 2k ±0.1%, 1/8W	340174	91637	MFF1-82001B	1		
R9	Res, mf, 1k ±0.1%, 1/8W	340380	91637	MFF1-81001BS	1		
R10	Res, comp, 47k ±5%, 1W	150219	01121	GB4735	1		
R11, R29	Res, comp, 1M ±5%, ¼W	182204	01121	CB1055	2		
R12	Res, mf, 26.7k ±0.1%, 1/8W	344465	91637	MFF1-82672B	1		

A1A1 THERMOMETER PCB ASSEMBLY (Cont.)

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R13	Res, mf, 150k ±1%, 1/8W	241083	91637	MFF1-81503F	1		
R15	Res, var, 50k ±20%, ½W	330688	71450	190PC503B	1	1	
R16, R17	Res, mf, 14.7k ±1%, 1/8W	226225	91637	MFF1-81472F	2		
R18	Res, comp, 470 ±5%, ¼W	147983	01121	CB4715	1		
R20	Res, mf, 28.7k ±1%, 1/8W	235176	91637	MFF1-82872F	1		
R21	Res, mf, 61.9k ±1%, 1/8W	237230	91637	MFF1-86192F	1		
R22	Res, mf, 19.1k ±1%, 1/8W	234963	91637	MFF1-81912F	1		
R23	Res, mf, 1k ±1%, 1/8W	168229	91637	MFF1-81001F	1		
R24, R25	Res, mf, 82.5k ±1%, 1/8W	246223	91637	MFF1-88242F	1		
R26	Res, comp, 680k ±5%, ¼W	188433	01121	CB6845	1		
R27	Res, comp, 100 ±5%, ¼W	147926	01121	CB1015	1		
R28, R33	Res, comp, 220k ±5%, ¼W	160937	01121	CB2245	2		
R30, R32	Res, comp, 20k ±5%, ¼W	221614	01121	CB2035	2		
R38	Res, comp, 68 ±5%, ¼W	147918	01121	CB6805	1		
R39	Res, comp, 2k ±5%, ¼W	202879	01121	CB2025	1		
R40	Res, comp, 22 ±5%, ¼W	147884	01121	CB2205	1		
R41	Res, comp, 330 ±5%, ¼W	147967	01121	CB3315	1		
R42	Res, comp, 9.1 ±5%, ½W	218768	01121	EB9R105	1		
R43 thru R46	Res, comp, 27k ±5%, ¼W	148148	01121	CB2735	4		
S1,S2, S3	Switch Assembly, pushbutton	428498	89536	428498	1	1	
S4	Switch, slide, 4 pdt	428615	82389	53212L	1	1	
S5	Switch, slide, dpdt	423129	95146	SLS-220-1	1	1	
T2	Xfmr, inverter	436097	89536	436097	1		
U1	IC, dual opnl ampl	404087	49956	RC4739DP	1	1	
U2	IC, opnl ampl	352195	49956	RC311DN	1	1	

A1A1 THERMOMETER PCB ASSEMBLY (Cont.)

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
U5	IC, TTL, bcd-to-7 segment decoder/driver	340109	01295	SN7447AN	1	1	
U6	IC, res network, 60Ω	344069	89536	344069	1	1	
U7	IC, C-MOS, hex buffer/inverter	381830	01295	MM5650AN	1	1	
U8	IC, linear, voltage regulator, +15V	413187	12040	LM340T-18	1	1	
U9	IC, linear, voltage regulator, −12V	381665	04713	MC7912CP	1	1	
VR1	Diode, zener, 6.4V ±2%	393579	04713	1N4567	1	1	
VR2	Diode, zener, 6.2V	325811	07910	1N753A	1	1	
VR3	Diode, zener, 7.5V	256446	07910	1N755A	1	1	
Y1	Crystal, 400 kHz	403352	89536	403352	1		
1	Button, dark gray	419689	89536	419689	1		
2	Button, light gray	412163	89536	412163	1		
3	Button, green	419747	89536	419747	1		
4	Connector, ac line						
	Contact, ground	338640	89536	338640	1		
	Contact, voltage	338657	89536	338657	2		
	Insulator, paper	344184	89536	344184	1		
	Insulator, plastic	338624	89536	338624	1		
5	Holder Assembly, Battery						
	Contact, battery	344200	89536	344200	8		
	Holder, battery	390450	89536	390450	4		
	Hold down, battery	347427	89536	347427	2		
6	Isothermal Block						
	Insulator	415695	89536	415695	1		
	Plate, terminal, neg	415687	89536	415687	1		
	Plate, terminal, pos	415679	89536	415679	1		
7	Socket, IC, 40-pin	418988	91506	340-AG37D	1		

A2 DISPLAY PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
A2	**DISPLAY PCB ASSEMBLY (2165A-4002)** **Figure 8-2**	421189	89536	421189	REF		
DS1, DS2	LED, dual 7-segment character display	419051	29083	MAN 6610	2	1	
DS3	LED, 7-segment character display	407874	29083	MAN 4610	1	1	
P4	Connector, female, 16-pin	375329	00779	85863-3	1		
R1	Res, comp, 91 ±5%, ¼W	221887	01121	CB9105	1		

A3 TYPE SELECT PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
A3	**TYPE SELECT PCB ASSEMBLY** **Figure 8-3**				REF		
	J Type (2160A-4016)	415653	89536	415653			
P3	Socket, IC, 8-pin	418608	00779	583640-1	1		
R1	Res, mf, 10.7k ±1%, 1/8W	423681	91637	MFF1-81072F	1		
R2	Res, mf, 619 ±0.1%, 1/8W	423715	91637	MFF1-86190B	1		
	K Type (2160A-4017)	415661	89536	415661			
P3	Socket, IC, 8-pin	418608	00779	583640-1	1		
R1	Res, mf, 3.74k ±1%, 1/8W	260547	91637	MFF1-83741F	1		
R2	Res, mf, 481.4 ±0.1%, 1/8W	423723	91637	MFF1-8481R4B	1		
	T Type (2160A-4018)	415927	89536	415927			
P3	Socket, IC, 8-pin	418608	00779	583640-1	1		
R1	Res, mf, 3.74k ±1%, 1/8W	260547	91637	MFF1-83741F	1		
R2	Res, mf, 483.7 ±0.1%, 1/8W	423731	91637	MFF1-8483R7B	1		
	E Type (2160A-4019)	415935	89536	415935			
P3	Socket, IC, 8-pin	418608	00779	583640-1	1		
R1	Res, mf, 53.6k ±1%, 1/8W	291401	91637	MFF1-85362F	1		
R2	Res, mf, 732 ±0.1%, 1/8W	423749	91637	MFF1-87320B	1		

Section 6

Option & Accessory Information

6-1. INTRODUCTION

6-2. This section of the manual contains information concerning the Options and Accessories available for use with the Model 2175A Digital Thermometer. The first portion of this section provides a brief description of each option and accessory. The depth of detail is intended to give the prospective user an adequate first aquaintance with the features and capabilities of each. Detailed information concerning specifications, operating instructions, maintenance, list of replaceable parts and schematics is supplied separately with some options and accessories, and is designed to comprise the second portion of this section. Unique page and paragraph numbering is assigned to each of the add-on descriptions to allow separation into easily identifiable subsections. The material is prepunched (T-punched) to permit insertion without disassembling the manual. Table 6-1 lists the available options and accessories and defines the manner in which each is documented.

Table 6-1. 2175A OPTIONS, ACCESSORIES AND DOCUMENTATION SOURCES

MODEL OR OPTION NO.	DESCRIPTION	DOCUMENTATION SUPPLIED	
		WITH UNIT	HERE IN
C80	Carrying Case		●
C86	Carrying Case		●
P20J	J-Type TC Probe		●
P20K	K-Type TC Probe		●
P20T	T-Type TC Probe		●
M00-100-714	Front Panel Dust Cover		●
M00-200-611	Rack Mtg. Kit, Offset	●	
M00-200-612	Rack Mtg. Kit, Center	●	
M00-200-613	Rack Mtg. Kit, side-by-side	●	
2160A-7016	J-Type Select PCB		●
2160A-7017	K-Type Select PCB		●
2160A-7019	E-Type Select PCB		●
2160A-7018	T-Type Select PCB		●
2160A-7022	Interface Cable		●
–01	Battery Pack		●
–02	Digital Output Unit	○	
–04	Analog Output Unit	○	

○ = T-punched for insertion in Section 6 of this manual.
● = Not T-punched.

6-3. CARRYING CASE (C80)

6-4. The Model C80 Carrying Case, Figure 6-1, is a soft vinyl plastic container designed for the storage and transport of the 2175A. The case provides the unit with adequate protection against normal handling and storage conditions. In addition to a shoulder strap, the C80 is equipped with a storage compartment for probes, power cord, and other compact accessories.

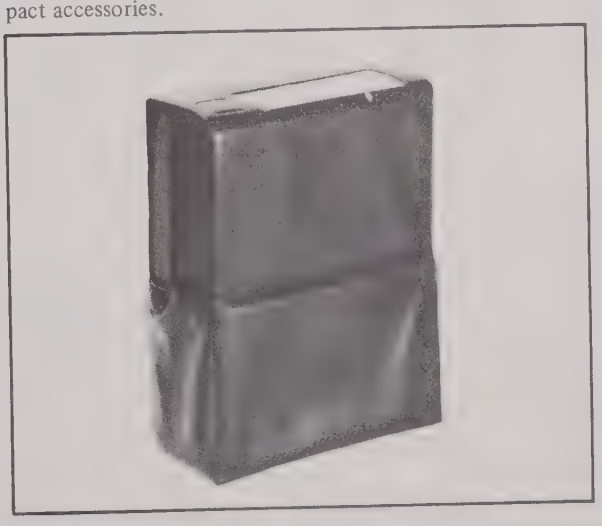


Figure 6-1. C80 CARRYING CASE

6-5. CARRYING CASE (C86)

6-6. The Model C86 Carrying Case, Figure 6-2, is a molded polyethylene container, with handle, designed for use in transporting the 2175A. This rugged case provides the unit with maximum protection against rough handling and adverse weather conditions. A separate storage compartment is provided for probes, power cord, and other compact accessories.

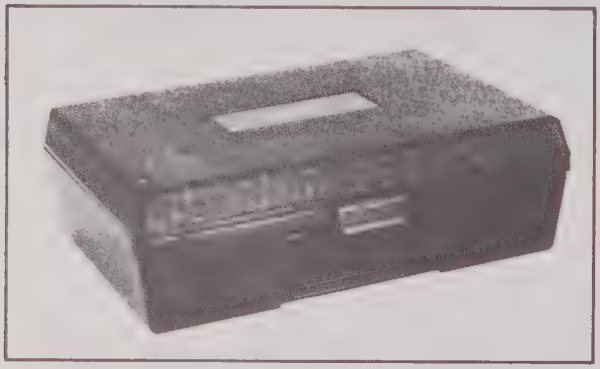


Figure 6-2. C86 CARRYING CASE

6-7. THERMOCOUPLE PROBES

6-8. Three types of thermocouple probe assemblies (J, K and T) are available from Fluke for use with the 2175A. See Table 6-1. Each thermocouple is enclosed in a 6-inch x 1/8 inch iconel sheath, and includes a heavy duty transition splice and spring. See Figure 6-3. The thermocouple junction is grounded to the sheath, and 36-inch trimmed leads are included on all units. Refer to the Tables under Specifications in Section 1 of this manual for the temperature ranges recommended for each thermocouple type.

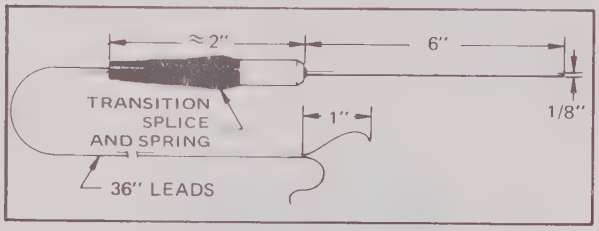


Figure 6-3. P20 SERIES PROBE

6-9. FRONT PANEL DUST COVER (M00-100-714)

6-10. The front panel dust cover is a molded plastic snap-on accessory which fits over the front panel of the 2175A. The dust cover provides protection for the front panel controls, and is useful when storing or transporting the unit.

6-11. RACK MOUNTING KITS

6-12. Three rack mounting kits are available for mounting the 2175A in a standard 19-inch equipment rack. The kits, listed in Table 6-1, provide the option of either offset mounting (left/right), center mounting or side-by-side mounting.

6-13. TYPE SELECT PCB's

6-14. A series of plug-in type select pcb's are available as accessories to allow the thermocouple compatibility of the 2175A to be changed by the user. The available pcb's are listed in Table 6-1; and the instructions necessary to interchange pcb's in the 2175A are given in Section 2 of this manual under Thermocouple Compatibility. Only one of the pcb's can be installed in the 2175A at any given time.

6-15. INTERFACE CABLE (2160A-7022)

6-16. The Interface Cable is a 6-foot, ribbon cable and 34-pin connector designed to interface either the Analog Output Unit (Option –04) or the Digital Output Unit (Option –02) with an external piece of equipment. The connector is polarized and mates with the rear-panel connector of the Analog/Digital Output Unit. The connections to the free end of the cable are completed, as necessary, to interface the external device. Refer to the instructions provided with the Analog/Digital Output Unit for pin assignments.

6-17. BATTERY PACK, OPTION –01

6-18. Battery operation of the 2175A requires the installation of four, rechargeable, D-size, Nickel-Cadmium batteries. These batteries are field installable and are available from the John Fluke Mfg. Co., Inc. as the –01 Option. A charging circuit is included in the basic 2175A to charge the batteries. The batteries receive a trickle-charge during normal operation and a fast-charge when the Charge Mode is enabled. Typically, a fully charged set of batteries will allow 8 hours of portable operation. To fully charge a set of discharged batteries, operate the unit in the ON charge mode for 14 hours.

CAUTION!

The 2175A may be damaged if alkaline, zinc-carbon, or mercury batteries are charged in the unit. Use only Nickel-Cadmium batteries.

6-19. Installation

6-20. Use the following procedure for installing Ni-Cad batteries in the 2175A:

a. Disconnect line cord. Remove retaining screw at rear of instrument case, and remove instrument from case.

b. Remove the two threaded screws securing the battery holders.

c. Remove the holder tops and install the four Ni-Cad batteries. The polarities for proper installation are shown on the pcb next to the battery holders.

d. Install the battery holder tops and reassemble the unit.

6-21. Charging Ni-Cad Batteries

NOTE

Battery manufacturers recommend that Ni-Cad batteries be recharged at least every 90 days. Storage temperatures below +25°C are recommended.

6-22. With regard to the charging of Nickel-Cadmium batteries, there are some phenomena which should be considered. For instance, charging Ni-Cad batteries with cell case temperatures above 25°C will cause the cell's charge capacity to decrease. The decrease in capacity is linear from 100% of rated capacity at 25°C to only 60% of rated capacity at 50°C, and as low as 45% at 60°C. Cell case temperatures typically run from 5°C to 10°C above ambient temperature during charging due to heat dissipated by the charging circuit.

6-23. Charge capacity may also be affected by a cell's charging-discharging routine, due to a memory-type phenomenon. For instance, if a Ni-Cad battery pack is used in a daily routine where it is allowed to discharge by only 30% before being fully recharged again, it will eventually become a battery pack capable of delivering only 30% of its rated capacity. To return such a battery pack to its rated capacity, connect an external load which will discharge the battery completely at a rate equal to its capacity divided by 20. For example, a pack of four series-connected 1.2 volt cells having individual capacity ratings of 3.5 ampere hours should be discharged at a rate of 3.5A ÷ 20 = .175A. This requires a load resistor of 4.8V ÷ .175A = 27.5 ohms (approximate) with a power rating of at least (4.8V) (.175A) = .85W. (A 2-watt carbon composition resistor is suitable.)

6-24. Allow the battery pack to discharge for 30 hours, then charge the battery pack at twice the discharge rate for 20 hours. (In the example, the charging rate would be 0.35 amperes at 4.8 volts.) When charging is complete, discharge the pack at the capacity-divided-by-20 rate for 30 hours, then recharge at twice the discharge rate for a period of 20 hours. The battery pack should now be restored to its rated capacity.

6-25. DIGITAL OUTPUT UNIT, OPTION –02

NOTE

The Digital Output Unit is functional only when the 2175A is being operated from line power.

6-26. The Digital Output Unit (Option –02) is a field installable pcb that mounts on the interior of the 2175A and provides a digital output which is equivalent to the displayed measurement data. The digital output is positive-true, TTL compatible and is presented in bcd, character-parallel format. All displayed characters are represented at the output. Output data is solicited by an External Trigger input and valid data is ensured by Busy and $\overline{\text{Busy}}$ outputs.

6-27. External connections to the Digital Output Unit are made through a 34-pin connector which is supplied with the pcb. The connector is compatible with Amphenol's 34-wire standard ribbon cable. A 6-foot ribbon cable and connector is available as an accessory and is described earlier in this section under Interface Cable.

6-28. ANALOG OUTPUT UNIT, OPTION –04

NOTE

The Analog Output Unit is functional only when the 2175A is being operated from line power.

6-29. The Analog Output Unit is a field installable pcb assembly which provides the 2175A with a rear-panel analog output voltage proportional to the displayed measurement data. The output voltage is electrically isolated from the 2175A and covers a voltage range of –0.4 to +4V dc. Automatic polarity sensing is provided for both °C and °F measurements to ensure that the polarity of the output voltage agrees with the displayed polarity. Since the analog output terminals are isolated from the 2175A, the output voltage is referenced to the low terminal of the external recording device (voltmeter, strip-chart recorder, etc.).

6-30. External connections to the Analog Output Unit are made through a 34-pin connector which is supplied with the pcb. The connector is compatible with Amphenol's 34-wire standard ribbon cable. A 6-foot ribbon cable and connector is available as an accessory and is described earlier in this section under Interface Cable.

Section 7
General Information

7-1. This section of the manual contains generalized user information as well as supplemental information to the Lists of Replaceable parts contained in Section 5. The following information is presented in this section:

TABLE	TITLE	PAGE
7-1.	List of Abbreviations	7-2
7-2.	Federal Supply Codes for Manufacturers	7-3
7-3.	Fluke Technical Service Centers	7-7
7-4.	International Service Centers	7-7
7-5.	Sales Representatives-Domestic	7-8
7-6.	Sales Representatives-International	7-9

Table 7-1. LIST OF ABBREVIATIONS AND SYMBOLS

A or amp	ampere
ac	alternating current
af	audio frequency
a/d	analog-to-digital
assy	assembly
AWG	american wire gauge
B	bel
bcd	binary coded decimal
^{o}C	Celsius
cap	capacitor
ccw	counterclockwise
cer	ceramic
cermet	ceramic to metal(seal)
ckt	circuit
cm	centimeter
cmrr	common mode rejection ratio
comp	composition
cont	continue
crt	cathode-ray tube
cw	clockwise
d/a	digital-to-analog
dac	digital-to-analog converter
dB	decibel
dc	direct current
dmm	digital multimeter
dvm	digital voltmeter
elect	electrolytic
ext	external
F	farad
^{o}F	Fahrenheit
FET	Field-effect transistor
ff	flip-flop
freq	frequency
FSN	federal stock number
g	gram
G	giga (10^{9})
gd	guard
Ge	germanium
GHz	gigahertz
gmv	guaranteed minimum value
gnd	ground
H	henry
hd	heavy duty
hf	high frequency
Hz	hertz
IC	integrated circuit
if	intermediate frequency
in	inch(es)
intl	internal
I/O	input/output
k	kilo (10^{3})
kHz	kilohertz
kΩ	kilohm(s)
kV	kilovolt(s)
lf	low frequency
LED	light-emitting diode
LSB	least significant bit
LSD	least significant digit
M	mega (10^{6})
m	milli (10^{-3})
mA	milliampere(s)
max	maximum
mf	metal film
MHz	megahertz
min	minimum
mm	millimeter
ms	millisecond
MSB	most significant bit
MSD	most significant digit
MTBF	mean time between failures
MTTR	mean time to repair
mV	millivolt(s)
mv	multivibrator
MΩ	megohm(s)
n	nano (10^{-9})
na	not applicable
NC	normally closed
(–) or neg	negative
NO	normally open
ns	nanosecond
opnl ampl	operational amplifier
p	pico (10^{-12})
para	paragraph
pcb	printed circuit board
pF	picofarad
pn	part number
(+) or pos	positive
pot	potentiometer
p-p	peak-to-peak
ppm	parts per million
PROM	programmable read-only memory
psi	pound-force per square inch
RAM	random-access memory
rf	radio frequency
rms	root mean square
ROM	read-only memory
s or sec	second (time)
scope	oscilloscope
SH	shield
Si	silicon
serno	serial number
sr	shift register
Ta	tantalum
tb	terminal board
tc	temperature coefficient or temperature compensating
tcxo	temperature compensated crystal oscillator
tp	test point
u or μ	micro (10^{-6})
uhf	ultra high frequency
us or μs	microsecond(s) (10^{-6})
uut	unit under test
V	volt
v	voltage
var	variable
vco	voltage controlled oscillator
vhf	very high frequency
vlf	very low frequency
W	watt(s)
ww	wire wound
xfmr	transformer
xstr	transistor
xtal	crystal
xtlo	crystal oscillator
Ω	ohm(s)
μ	micro (10^{-6})

Table 7-2. FEDERAL SUPPLY CODES FOR MANUFACTURERS

00213
Nytronics Comp. Group Inc.
Subsidiary of Nytronics Inc.
Formerly Sage Electronics
Rochester, New York

00327
Welwyn International, Inc.
Westlake, Ohio

00656
Aerovox Corp.
New Bedford, Massachusetts

00686
Film Capacitors, Inc.
Passaic, New Jersey

00779
AMP Inc.
Harrisberg, Pennsylvania

01121
Allen-Bradley Co.
Milwaukee, Wisconsin

01281
TRW Electronic Comp.
Semiconductor Operations
Lawndale, California

01295
Texas Instruments, Inc.
Semiconductor Group
Dallas, Texas

01537
Motorola Communications &
Electronics Inc.
Franklin Park, Illinois

01686
RCL Electronics Inc.
Manchester, New Hampshire

01730
Replaced by 73586

01884 - use 56289
Sprague Electric Co.
Dearborn Electronic Div
Lockwood, Florida

02114
Ferroxcube Corp.
Saugerties, New York

02131
General Instrument Corp.
Harris ASW Div.
Westwood, Maine

02395
Rason Mfg. Co.
Brooklyn, New York

02533
Snelgrove, C.R. Co., Ltd.
Don Mills, Ontario, Canada
M3B 1M2

02606
Fenwal Labs
Div. of Travenal Labs.
Morton Grove, Illinois

02660
Bunker Ramo Corp., Conn Div.
Formerly Amphenol-Borg
Electric Corp.
Broadview, Illinois

02799
Areo Capacitors, Inc.
Chatsworth, California

03508
General Electric Co.
Semiconductor Products
Syracuse, New York

03614
Replaced by 71400

03651
Replaced by 44655

03797
Eldema Div.
Genisco Technology Corp.
Compton, California

03877
Transistron Electronic Corp.
Wakefield, Massachusetts

03888
KDI Pyrofilm Corp.
Whippany, New Jersey

03911
Clairex Electronics Div.
Clairex Corp.
Mt. Vernon, New York

03980
Muirhead Inc.
Mountainside, New Jersey

04009
Arrow Hart Inc.
Hartford, Connecticut

04062
Replaced by 72136

04202
Replaced by 81312

04217
Essex International Inc.
Wire & Cable Div.
Anaheim, California

04221
Aemco, Div. of
Midtex Inc.
Mankato, Minnesota

04222
AVX Ceramics Div.
AVX Corp.
Myrtle Beach, Florida

04423
Telonic Industries
Laguna Beach, California

04645
Replaced by 75376

04713
Motorola Inc. Semiconductor
Products
Phoenix, Arizona

04946
Standard Wire & Cable
Los Angeles, California

05082
Replaced by 94988

05236
Jonathan Mfg. Co.
Fullerton, California

05245
Components Corp. now
Corcom, Inc.
Chicago, Illinois

05277
Westinghouse Electric Corp.
Semiconductor Div.
Youngwood, Pennsylvania

05278
Replaced by 43543

05279
Southwest Machine &
Plastic Co.
Glendora, California

05397
Union Carbide Corp.
Materials Systems Div.
New York, New York

05571 - use 56289
Sprague Electric Co.
Pacific Div.
Los Angeles, California

05574
Viking Industries
Chatsworth, California

05704
Replaced by 16258

05820
Wakefield Engineering Inc.
Wakefield, Massachusetts

06001
General Electric Co.
Electronic Capacitor &
Battery Products Dept.
Columbia, South Carolina

06136
Replaced by 63743

06383
Panduit Corp.
Tinley Park, Illinois

06473
Bunker Ramo Corp.
Amphenol SAMS Div.
Chatsworth, California

06555
Beede Electrical Instrument Co.
Penacook, New Hampshire

06739
Electron Corp.
Littleton, Colorado

06743
Clevite Corp.
Cleveland, Ohio

06751
Components, Inc. Semcor Div.
Phoenix, Arizona

06860
Gould Automotive Div.
City of Industry, California

06961
Vernitron Corp., Piezo
Electric Div.
Formerly Clevite Corp., Piezo
Electric Div.
Bedford, Ohio

06980
Eimac Div.
Varian Associates
San Carlos, California

07047
Ross Milton, Co., The
South Hampton, Pennsylvania

07115
Replaced by 14674

07138
Westinghouse Electric Corp.,
Electronic Tube Division
Horsehead, New York

07233
TRW Electronic Components
Cinch Graphic
City of Industry, California

07256
Silicon Transistor Corp.
Div. of BBF Group Inc.
Chelmsford, MA

07261
Aumet Corp.
Culver City, California

07263
Fairchild Semiconductor
Div. of Fairchild Camera
& Instrument Corp.
Mountain View, California

07344
Bircher Co., Inc.
Rochester, New York

07597
Burndy Corp.
Tape/Cable Div.
Rochester, New York

07792
Lerma Engineering Corp.
Northampton, Massachusetts

07910
Teledyne Semiconductor
Formerly Continental Device
Hawthorne, California

07933 - use 49956
Raytheon Co.
Semiconductor Div. HQ
Mountain View, California

08225
Industro Transistor Corp.
Long Island City, New York

08261
Spectra Strip Corp.
Garden Grove, California

08530
Reliance Mica Corp.
Brooklyn, New York

08806
General Electric Co.
Miniature Lamp Products Dept.
Cleveland, Ohio

08863
Nylomatic Corp.
Norrisville, Pennsylvania

08988 - use 53085
Skottie Electronics Inc.
Archbald, Pennsylvania

09214
G.E. Co. Semi-Conductor
Products Dept.
Power Semi-Conductor
Products OPN Sec.
Auburn, New York

09353
C and K Components
Watertown, Massachusetts

09423
Scientific Components, Inc.
Santa Barbara, California

09922
Burndy Corp.
Norwalk, Connecticut

09969
Dale Electronics Inc.
Yankton, S. Dakota

10059
Barker Engineering Corp.
Formerly Amerace, Amerace
ESNA Corp.
Kenilworth, New Jersey

11236
CTS of Berne
Berne, Indiana

11237
CTS Keene Inc.
Paso Robles, California

11358
CBS Electronic Div.
Columbia Broadcasting System
Newburyport, MN

11403
Best Products Co.
Chicago, Illinois

11503
Keystone Columbia Inc.
Warren, Michigan

11532
Teledyne Relays
Hawthorne, California

11711
General Instrument Corp
Rectifier Division
Hickville, New York

11726
Qualidyne Corp.
Santa Clara, California

12014
Chicago Rivet & Machine Co.
Bellwood, Illinois

12040
National Semiconductor Corp.
Danburry, Connecticut

12060
Diodes, Inc.
Chatsworth, California

12136
Philadelphia Handle Co.
Camden, New Jersey

12300
Potter-Brumfield Division
AMF Canada LTD.
Guelph, Onatrio, Canada

12323
Presin Co., Inc.
Shelton, Connecticut

12327
Freeway Corp. formerly
Freeway Washer & Stamping Co.
Cleveland, Ohio

12443
Budd Co. The, Polychem Products
Plastic Products Div.
Bridgeport, PA

12615
U.S. Terminals Inc.
Cincinnati, Ohio

12617
Hamlin Inc.
Lake Mills, Wisconsin

12697
Clarostat Mfg. Co.
Dover, New Hampshire

12749
James Electronics
Chicago, Illinois

12856
Micrometals
Sierra Madre, California

12954
Dickson Electronics Corp.
Scottsdale, Arizona

12969
Unitrode Corp.
Watertown, Massachusetts

13103
Thermalloy Co., Inc.
Dallas, Texas

13327
Solitron Devices Inc.
Tappan, New York

13511
Amphenol Cadre Div.
Bunker-Ramo Corp.
Los Gatos, California

13606 - use 56289
Sprague Electric Co.
Transistor Div.
Concord, New Hampshire

13839
Replaced by 23732

14099
Semtech Corp.
Newbury Park, California

14140
Edison Electronic Div.
Mc Gray-Edison Co.
Manchester, New Hampshire

14193
Cal-R-Inc. formerly
California Resistor, Corp.
Santa Monica, California

14298
American Components, Inc.
an Insilco Co.
Conshohocken, Pennsylvania

14655
Cornell-Dublier Electronics
Division of Federal Pacific
Electric Co. Govt. Control Dept.
Newark, New Jersey

14752
Electro Cube Inc.
San Gabriel, California

14869
Replaced by 96853

14936
General Instrument Corp.
Semi Conductor Products Group
Hicksville, New York

15636
Elec-Trol Inc.
Saugus, California

15801
Fenwal Electronics Inc.
Div. of Kidde Walter and Co., Inc.
Framingham, Massachusetts

15818
Teledyne Semiconductors, formerly
Amelco Semiconductor
Mountain View, California

15849
Litton Systems Inc. Useco Div.
formerly Useco Inc.
Van Nuys, California

15898
International Business
Machines Corp.
Essex Junction, Vermont

15909
Replaced by 14140

16258
Space-Lok Inc.
Burbank, California

16299
Corning Glass
Electronic Components Div.
Raleigh, North Carolina

16332
Replaced by 28478

16473
Cambridge Scientific Ind.
Div. of Chemed Corporation
Cambridge, Maryland

16742
Paramount Plastics Fabricators, Inc.
Downey, California

16758
Delco Electronics
Div. of General Motors Corp.
Kokomo, Indiana

17001
Replaced by 71468

17069
Circuit Structures Lab.
Burbank, California

17338
High Pressure Eng. Co., Inc.
Oklahoma City, Oklahoma

17545
Atlantic Semiconductors, Inc.
Asbury Park, New Jersey

17856
Siliconix, Inc.
Santa Clara, California

17870
Replaced by 14140

18178
Vactec Inc.
Maryland Heights, Missouri

18324
Signetics Corp.
Sunnyvale, California

18612
Vishay Resistor Products Div.
Vishay Intertechnology Inc.
Malvern, Pennsylvania

18736
Voltronics Corp.
Hanover, New Jersey

18927
G T E Sylvania Inc.
Precision Material Group
Parts Division
Titusville, Pennsylvania

19451
Perine Machinery & Supply Co.
Seattle, Washington

19701
Electro-Midland Corp.
Mepco-Electra Inc.
Mineral Wells, Texas

20584
Enochs Mfg. Inc.
Indianapolis, Indiana

20891
Self-Organizing Systems, Inc.
Dallas, Texas

21604
Buckeye Stamping Co.
Columbus, Ohio

21845
Solitron Devices Inc.
Transistor Division
Riveria Beach, Florida

22767
ITT Semiconductors
Palo Alto, California

23050
Product Comp. Corp.
Mount Vernon, New York

23732
Tracor Inc.
Rockville, Maryland

23880
Stanford Applied Engrng.
Santa Clara, California

23936
Pamotor Div., Wm. J. Purdy Co.
Burlingame, California

24248
Replaced by 94222

24355
Analog Devices Inc.
Norwood, Massachusetts

24655
General Radio
Concord, Massachusetts

24759
Lenox-Fugle Electronics Inc.
South Plainfield, New Jersey

25088
Siemen Corp.
Isilen, New Jersey

25403
Amperex Electronic Corp.
Semiconductor &
Micro-Circuits Div.
Slatersville, Rhode Island

27014
National Semiconductor Corp.
Santa Clara, California

27264
Molex Products
Downers Grove, Illinois

28213
Minnesota Mining & Mfg. Co.
Consumer Products Div.
St. Paul, Minnesota

28425
Serv-/-Link formerly
Bohannan Industries
Fort Worth, Texas

28478
Deltrol Controls Div.
Deltrol Corporation
Milwaukee, Wisconsin

28480
Hewlett Packard Co. Corporate H.Q.
Palo Alto, California

28520
Heyman Mfg. Co.
Kenilworth, New Jersey

29083
Monsanto, Co., Inc.
Santa Clara, California

29604
Stackpole Components Co.
Raleigh, North Carolina

30148
A B Enterprise Inc.
Ahoskie, North Carolina

30323
Illinois Tool Works, Inc.
Chicago, Illinois

31091
Optimax Inc.
Colmar, Pennsylvania

32539
Mura Corp.
Great Neck, New York

32767
Griffith Plastic Corp.
Burlingame, California

32879
Advanced Mechanical Components
Northridge, California

32897
Erie Technological Products, Inc.
Frequency Control Div.
Carlisle, Pennsylvania

32997
Bourns Inc.
Trimpot Products Division
Riverside, California

33173
General Electric Co.
Products Dept.
Owensboro, Kentucky

Table 7-2. FEDERAL SUPPLY CODES FOR MANUFACTURERS (Continued)

34333
Silicon General
Westminister, California

34335
Advanced Micro Devices
Sunnyvale, California

34802
Electromotive Inc.
Kenilworth, New Jersey

37942
Mallory, P.R. & Co., Inc.
Indianapolis, Indiana

42498
National Radio
Melrose, Massachusetts

43543
Nytronics Inc.
Transformer Co. Div.
Geneva, New York

44655
Ohmite Mfg. Co.
Skokie, Illinois

49671
RCA Corp.
New York, New York

49956
Raytheon Company
Lexington, Massachusetts

50088
Mostek Corp.
Carrollton, Texas

50579
Litronix Inc.
Cupertino, California

51605
Scientific Components Inc.
Linden, New Jersey

53021
Sangamo Electric Co.
Springfield, Illinois

54294
Cutler-Hammer Inc. formerly
Shallcross, A Cutter-Hammer Co.
Selma, North Carolina

55026
Simpson Electric Co.
Div. of Am. Gage and Mach. Co.
Elgin, Illinois

56289
Sprague Electric Co.
North Adams, Massachusetts

58474
Superior Electric Co.
Bristol, Connecticut

60399
Torin Corp, formerly
Torrington Mfg. Co.
Torrington, Connecticut

63743
Ward Leonard Electric Co., Inc.
Mount Vernon, New York

64834
West Mfg. Co.
San Francisco, Californai

65092
Weston Instruments Inc.
Newark, New Jersey

66150
Winslow Tele-Tronics Inc.
Eaton Town, New Jersey

70485
Atlantic India Rubber Works
Chicago, Illinois

70563
Amperite Company
Union City, New Jersey

70903
Belden Corp.
Geneva, Illinois

71002
Birnbach Radio Co., Inc.
Freeport, LI New York

71400
Bussmann Mfg.
Div. of McGraw-Edison Co.
Saint Louis, Missouri

71450
CTS Corp.
Elkhart, Indiana

71468
ITT Cannon Electric Inc.
Santa Ana, California

71482
Clare, C.P. & Co.
Chicago, Illinois

71590
Centrelab Electronics
Div. of Globe Union Inc.
Milwaukee, Wisconsin

71707
Coto Coil Co., Inc.
Providence, Rhode Island

71744
Chicago Miniature Lamp Works
Chicago, Illinois

71785
TRW Electronics Components
Cinch Connector Operations Div.
Elk Grove Village, Chicago, Illinois

72005
Driver, Wilber B., Co.
Newark, New Jersey

72092
Replaced by 06980

72136
Electro Motive Mfg. Co.
Williamantic, Connecticut

72259
Nytronics Inc.
Pelham Manor, New Jersey

72619
Dialight Div.
Amperex Electronic Corp.
Brooklyn, New York

72653
G.C. Electronics
Div. of Hydrometals, Inc.
Brooklyn, New York

72665
Replaced by 90303

72794
Dzus Fastener Co., Inc.
West Islip, New York

72928
Gulton Ind. Inc.
Gudeman Div.
Chicago, Illinois

72982
Erie Tech. Products Inc.
Erie, Pennsylvania

73138
Beckman Instruments Inc.
Helipot Division
Fullerton, California

73293
Hughes Aircraft Co.
Electron Dynamics Div.
Torrence, California

73445
Amperex Electronic Corp.
Hicksville, LI, New York

73559
Carling Electric Inc.
West Hartford, Connecticut

73586
Circle F Industries
Trenton, New Jersey

73734
Federal Screw Products, Inc.
Chicago, Illinois

73743
Fischer Special Mfg. Co.
Cincinnati, Ohio

73899
JFD Electronics Co.
Components Corp
Brooklyn, New York

73949
Guardian Electric Mfg. Co.
Chicago, Illinois

74199
Quan Nichols Co.
Chicago, Illinois

74217
Radio Switch Corp.
Marlboro, New Jersey

74276
Signalite Div.
General Instrument Corp.
Neptune, New Jersey

74306
Piezo Crystal Co.
Carlisle, Pennsylvania

74542
Hoyt Elect. Instr. Works
Penacook, New Hampshire

74970
Johnson E.F., Co.
Waseca, Minnesota

75042
TRW Electronics Components
IRC Fixed Resistors
Philadelphia, Pennsylvania

75376
Kurz-Kasch Inc.
Dayton, Ohio

75378
CTS Knights Inc.
Sandwich, Illinois

75382
Kulka Electric Corp.
Mount Vernon, New York

75915
Littlefuse Inc.
Des Plaines, Illinois

76854
Oak Industries Inc.
Switch Div.
Crystal Lake, Illinois

77342
AMF Inc.
Potter & Brumfield Div.
Princeton, Indiana

77638
General Instrument Corp.
Rectifier Division
Brooklyn, New York

77969
Rubbercraft Corp. of CA. LTD.
Torrance, California

78189
Shakeproof
Div. of Illinois Tool Works Inc.
Elgin, Illinois

78277
Sigma Instruments, Inc.
South Braintree, Massachusetts

78488
Stackpole Carbon Co.
Saint Marys, Pennsylvania

78553
Eaton Corp. Engineered
Fastener Div.
Tinnerman Plant
Cleveland, Ohio

79136
Waldes Kohinoor Inc.
Long Island City, New York

79497
Western Rubber Company
Goshen, Indiana

79963
Zierick Mfg. Corp.
Mt. Kisko, New York

80031
Electro-Midland Corp., Mepco Div.
A North American Phillips Co.
Morristown, New Jersey

80145
LFE Corp., Process Control Div.
formerly API Instrument Co.
Chesterland, Ohio

80183 - use 56289
Sprague Products
North Adams, Massachusetts

80294
Bourns Inc., Instrument Div.
Riverside, California

80583
Hammarlund Mfg. Co., Inc.
Red Bank, New Jersey

80640
Stevens, Arnold Inc.
South Boston, Massachusetts

81073
Grayhill, Inc.
La Grange, Illinois

81312
Winchester Electronics
Div. of Litton Industries Inc.
Oakville, Connecticut

81439
Therm-O-Disc Inc.
Mansfield, Ohio

81483
International Rectifier Corp.
Los Angeles, California

81590
Korry Mfg. Co.
Seattle, Washington

81741
Chicago Lock Co.
Chicago, Illinois

82305
Palmer Electronics Corp.
South Gate, California

82389
Switchcraft Inc.
Chicago, Illinois

Table 7-2. FEDERAL SUPPLY CODES FOR MANUFACTURERS (Continued)

82415
North American Phillips
Controls Corp.
Frederick, Maryland

82872
Roanwell Corp.
New York, New York

82877
Rotron Inc.
Woodstock, New York

82879
ITT Royal Electric Div.
Pawtucket, Rhode Island

83003
Varo Inc.
Garland, Texas

83058
Carr Co., The United Can Div.
of TRW
Cambridge, Massachusetts

83298
Bendix Corp.
Electric Power Division
Eatontown, New Jersey

83330
Smith, Herman H., Inc.
Brooklyn, New York

83478
Rubbercraft Corp. of America, Inc.
West Haven, Connecticut

83594
Burroughs Corp.
Electronic Components Div.
Plainfield, New Jersey

83740
Union Carbide Corp.
Battery Products Div.
formerly Consumer Products Div.
New York, New York

84171
Arco Electronics
Great Neck, New York

84411
TRW Electronic Components
TRW Capacitors
Ogallala, Nebraska

84613
Fuse Indicator Corp.
Rockville, Maryland

84682
Essex International Inc.
Industrial Wire Div.
Peabody, Massachusetts

86577
Precision Metal Products,
of Malden Inc.
Stoneham, Massachusetts

86684
Radio Corp. of America
Electronic Components Div.
Harrison, New Jersey

86928
Seastrom Mfg. Co., Inc.
Glendale, California

87034
Illuminated Products Inc.
Subsidiary of Oak Industries Inc.
Anahiem, California

88219
Gould Inc.
Industrial Div.
Trenton, New Jersey

88245
Litton Systems Inc.
Useco Div.
Van Nuys, California

88419
Cornell-Dubilier Electronic Div.
Federal Pacific Co.
Fuquay-Varian, North Carolina

88486
Plastic Wire & Cable
Jewitt City, Connecticut

88690
Replaced by 04217

89536
Fluke, John Mfg. Co., Inc.
Seattle, Washington

89730
G.E. Co., Newark Lamp Works
Newark, New Jersey

90201
Mallory Capacitor Co. Div of
P.R. Mallory Co., Inc.
Indianapolis, Indiana

90211 - use 56365
Square D Co.
Chicago, Illinois

90215
Best Stamp & Mfg. Co.
Kansas City, Missouri

90303
Mallory Battery Co.
Div. of Mallory Co., Inc.
Tarrytown, New York

91094
Essex International Inc.
Suglex/IWP Div.
Newmarket, New Hampshire

91293
Johanson Mfg. Co.
Boonton, New Jersey

91407
Replaced by 58474

91502
Associated Machine
Santa Clara, California

91506
Augat Inc.
Attleboro, Massachusetts

91637
Dale Electronics Inc.
Columbus, Nebraska

91662
Elco Corp.
Willow Grove, Pennsylvania

91737 - use 71468
Gremar Mfg. Co., Inc.
ITT Cannon/Gremar
Santa Ana, California

91802
Industrial Devices, Inc.
Edgewater, New Jersey

91833
Keystone Electronics Corp.
New York, New York

91836
King's Electronics Co., Inc.
Tuckahoe, New York

91929
Honeywell Inc.
Micro Switch Div.
Freeport, Illinois

91934
Miller Electric Co., Inc.
Div of Aunet
Woonsocket, Rhode Island

92194
Alpha Wire Corp.
Elizabeth, New Jersey

93332
Sylvania Electric Products
Semiconductor Products Div.
Woburn, Massachusetts

94145
Replaced by 49956

94154 - use 94988
Wagner Electric Corp.
Tung-Sol Div.
Newark, New Jersey

94222
Southco Inc. formerly
South Chester Corp.
Lester, Pennsylvania

95146
Alco Electronic Products Inc.
Lawrence, Massachusetts

95263
Leecraft Mfg. Co.
Long Island City, New York

95264
Replaced by 98278

95275
Vitramon Inc.
Bridgeport, Connecticut

95303
RCA Corp.
Receiving Tube Div.
Cincinnati, Ohio

95348
Gordo's Corp.
Bloomfield, New Jersey

95354
Methode Mfg. Corp.
Rolling Meadows, Illinois

95712
Bendix Corp.
Electrical Components Div.
Microwave Devices Plant
Franklin, Indiana

95987
Weckesser Co. Inc.
Chicago, Illinois

96733
San Fernando Electric Mfg. Co.
San Fernando, California

96853
Gulton Industries Inc.
Measurement and Controls Div.
formerly Rustrak Instruments Co.
Manchester, New Hampshire

96881
Thomson Industries, Inc.
Manhasset, New York

97540
Master Mobile Mounts
Div. of Whitehall Electronics Corp.
Ft. Meyers, Florida

97913
Industrial Electronic Hdware Corp.
New York, New York

97945
Penwalt Corp.
SS White Industrial Products Div.
Piscataway, New Jersey

97966
Replaced by 11358

98094
Replaced by 49956

98159
Rubber-Teck, Inc.
Gardena, California

98278
Malco A Microdot Co., Inc.
Connector & Cable Div.
Pasadena, California

98291
Sealectro Corp.
Mamaroneck, New York

98388
Royal Industries
Products Div.
San Diego, California

98743
Replaced by 12749

98925
Replaced by 14433

99120
Plastic Capacitors, Inc.
Chicago, Illinois

99217
Bell Industries Elect. Comp. Div.
formerly Southern Elect. Div.
Burbank, California

99392
STM
Oakland, California

99515
ITT Jennings Monrovia Plant
Div. of ITT Jennings formerly
Marshall Industries Capacitor Div.
Monrovia, California

99779 - use 29587
Bunker-Ramo Corp.
Barnes Div.
Landsdowne, Pennsylvania

99800
American Precision Industries Inc.
Delevan Division
East Aurora, New York

99942
Centrelab Semiconductor
Centrelab Electronics Div. of
Globe-Union Inc.
El Monte, California

Toyo Electronics
(R-Ohm Corp.)
Irvine, California

National Connector
Minneapolis, Minnesota

Table 7-3. FLUKE TECHNICAL SERVICE CENTERS

United States

CALIFORNIA

Burbank
Fluke Western Tecnical Center
Mike Nagy, Service Manager
2020 N. Lincoln St.
Zip: 91504
Tel. (213) 849-4641

Santa Clara
Fluke Western Technical Center
Tom Marshall, Service Manager
2359 De La Cruz Blvd.
Zip: 95050
Tel. (408) 985-1200

COLORADO

Denver
Fluke Southwestern
Technical Center
Mel Suelzle, Service Manager
1980 S. Quebec St.
Unit 4
Zip: 80231
Tel. (303) 750-1228

FLORIDA

Orlando
Fluke S.E. Technical Center
Jesse Morse, Service Manger
P.O. Box 6578
940 N. Fern Creek Ave.
Zip: 32803
Tel. (305) 896-2296

ILLINOIS

Des Plaines
Fluke Midwestern
Technical Center
Bruce Hunt, Service Manager
1287 N. Rand Road
Zip: 60016
Tel. (312) 298-7470

MARYLAND

Kensington
Fluke Mideastern
Technical Center
John Hines, Service Manager
11501 Huff Court
Zip: 20795
Tel. (301) 881-5300

MASSACHUSETTS

Lexington
Fluke N.E. Technical Center
Dick Zemba, Service Manager
109 Massachusetts Ave.
Zip: 02173
Tel. (617) 861-8620

MINNESOTA

Minneapolis
Fluke Midwestern
Technical Center
Robert Wayne, Br. Manager
10800 Lyndale Ave. So.
Zip: 55420
Tel. (612) 884-4541

NEW JERSEY

Totowa
Fluke Eastern Technical Center
Al La Fleur, Service Manager
500 Union Blvd.
Zip: 07512
Tel. (201) 742-3215

NEW YORK

Farmingdale, LI
Fluke Eastern Technical Center
Charles Vanek, Br. Manager
59Central Ave. Unit 3
Zip: 11735
Tel. (516) 752-1078

Rochester
Fluke Eastern Technical Center
Wayne Roth, Br. Service Manager
4515 Culver Road
Zip: 14622
Tel. (716) 342-6940

NORTH CAROLINA

Greensboro
Fluke S.E. Technical Center
Dwain Cox, Service Manager
P.O. Box 9619
1310 Beaman Place
Zip: 27408
Tel. (919) 273-1918

WASHINGTON

Mountlake Terrace
John Fluke Mfg. Co., Inc.
Bill Fetrow, Tech. Service Spvr.
7001 - 220th Ave. S.W.
Zip: 98043
Tel. (206) 774-2206

Canada

ALBERTA

Calgary
Fluke Canadian Technical Center
Dave Racinsky, Service Manager
3829 - 12th St. N.E.
Zip: T2E 6M5
Tel. (403) 261-0780

ONTARIO

Mississauga
Fluke Canadian Technical Center
Herb Duval, Service Manager
6427 Northam Drive
Zip: L4V 1J5
Tel. (416) 678-1500

Table 7-4. INTERNATIONAL SERVICE CENTERS

CENTRAL & SOUTH AMERICA

ARGENTINA
Coasin S.A.
Miguel Volpe, Service Manager
Virrey del Pino 4071
Buenos Aires, Argentina
Tel: 523185

BRAZIL
Ambriex S.A.
Col. Josue Dantas Martins Filho
Rua Ceara, 104 - 2° e 3° Andares
ZC-29
Rio de Janeiro GB, Brazil
Tel: 264-7406

Adolfo Toyomaro Ichiki,
Service Manager
Rua Tupi, 535
01233 **Sao Paulo SP,** Brazil
Tel: 52-7806 & 0912

ECUADOR
Proteco Coasin CIA, Ltda.
Ing Jaime Jaramillo
Apartado 228A
Quito, Ecuador
Tel: 526759

MEXICO
Mexitek, S.A.
Enrique Batista Mangas,
Service Manager
Eugenia 408
Department 1
Mexico 12, D.F.
Mexico
Tel: 5360910 - 5239751

VENEZUELA
Coasin C.A.
Leslie Dunia, Service Manager
Apdo. Postal 50939
Sabana Grande No. 1
Caracas 105, Venezuela
Tel: 722311 - 728662

EUROPE

FRANCE
M.B. Electronique S.A.
Serge Pison, Service Manager
29, Rue Emile Duclaux
92150, **Suresnes,** France
Tel: 7723111 (108)

NETHERLANDS
C.N. Rood N.V.
Sieb Hoekstra, Service Manager
Cort van der Lindenstraat 11-13
P.O. Box 42
Rijswijk ZH 2100
Tel: 070-996360

Fluke (Nederland) B.V.
Henk Lit, Service Manager
P.O. Box 5053
Zevenheuvelenweg 53
Tilburg, Netherlands
Tel: (13) 673973

NORWAY
Morgenstierne & Co. A/S
Finn Schjervan
Konghellegate 3
P.O. Box 6688, Rodelokka
Oslo 5, Norway
Tel: 472 356110

UNITED KINGDOM
Fluke International Corporation
Ed Cutter, Service Manager
Garnet Close
Watford, WD2 4TT
England
Tel: 0923-33066

AFRICA, ASIA & AUSTRALIA

AUSTRALIA
Elmeasco Instruments Pty. Ltd.
Andrew McKean,
Service Manager
P.O. Box 30
Concord, N.S.W.
Australia 2137
Tel: (02) 736-2888

HONG KONG
Gilman & Co., Ltd.
J.B. Tetlow
P.O. Box 56
Hong Kong
Tel: 227011 (14)

INDIA
Hinditron Services Pvt. Ltd.
Chandu Vagal,
Service Manager
69/A.L. Jagmohandas Marg
Bombay —400 006, India
Tel: 365344

IRAN
Berkeh Company Ltd.
Tom Payne
20 Salm Road, Roosevelt Ave.
Tehran, Iran
Tel: 828294 831564

ISRAEL
R.D.T. Electronics Engineering
Ltd.
Shamai Ram-nof,
Service Manager
46, Sokolov Street
Ramat Hasharon 47235 Israel
Tel: 483211

JAPAN
Toyo Trading Company Ltd.
Mr. Adachi, Service Manager
P.O. Box 5014
International Tokyo
Tokyo 100-31, Japan
Tel: (03) 279-0771

SOUTH AFRICA
Fluke (Pty) Ltd.
P.O. Box 13091
Benoni 1511
Transvaal
Republic of South Africa
Tel: 011-849-6811

For areas not listed, contact the Fluke Technical Center nearest you or contact Fluke directly at Mountlake Terrace, WA.

John Fluke Mfg. Co., Inc.
P.O. Box 43210, Mountlake Terrace, WA 98043
Tel: (206) 774-2211 Toll Free: (800) 426-0361 TWX: 910-449-2850 Telex: 32-0013 Cable: Fluke

United States

ALABAMA
Huntsville
BCS Associates, Inc.
P.O. Box 1273
3322 S. Memorial Parkway
Zip: 35807
Tel. (205) 881-6220

ALASKA
Anchorage
Harry Lang & Associates
1406 W. 47th Ave.
Zip: 99503
Tel. (907) 279-5741

ARIZONA
Phoenix
Barnhill Associates, Inc.
7319 E. Stetson Drive
Scottsdale, AZ 85251
Tel. (602) 947-7841

CALIFORNIA
Los Angeles
Instrument Specialists
Sales Group
John Fluke Mfg. Co., Inc.
2020 North Lincoln Street
Burbank, CA 91504
Tel. (213) 849-7181

Santa Clara
Instrument Specialists
Sales Group
John Fluke Mfg. Co., Inc.
2359 De La Cruz Blvd.
Zip: 95050
Tel. (408) 244-1505

COLORADO
Denver
Barnhill Associates, Inc.
1980 S. Quebec Street, Unit 4
Zip: 80231
Tel. (303) 750-1222

CONNECTICUT
Hartford
IRI Sales Group
John Fluke Mfg. Co., Inc.
P.O. Box 518
Glastonbury, CT 06033
Tel. (203) 633-0777

FLORIDA
Orlando
BCS Associates, Inc.
P.O. Box 6578
940 N. Fern Creek Ave.
Zip: 32803
Tel. (305) 896-4881

GEORGIA
Decatur
BCS Associates, Inc.
2522 Tanglewood Road
Zip: 30033
Tel: (404) 321-0980

HAWAII
Honolulu
Industrial Electronics, Inc.
P.O. Box 135
646 Queen Street
Zip: 96817
Tel. (808) 533-6095

ILLINOIS
Chicago
Cozzens & Cudahy Sales Group
John Fluke Mfg. Co., Inc.
1301 North Rand Road
Des Plaines, IL 60016
Tel. (312) 298-3600

INDIANA
Indianapolis
Cozzens & Cudahy Sales Group
John Fluke Mfg. Co., Inc.
Port O'Call Executive Center
21 Beachway Drive
Zip: 46224
Tel. (317) 244-2456

KANSAS
Kansas City, MO
Cozzens & Cudahy Sales Group
John Fluke Mfg. Co., Inc.
4406 Chouteau Traffic Way
Zip: 64117
Tel. (816) 454-5836

KENTUCKY
Louisville
BCS Associates, Inc.
4506 Freda Way
Valley Station, KY 40272
Tel. (502) 935-9634

MARYLAND
Baltimore
John Fluke Mfg. Co., Inc.
11501 Huff Court
Kensington, MD 20795
Tel. (301) 881-3370

MASSACHUSETTS
Boston
Instrument Representatives
Sales Group
John Fluke Mfg. Co., Inc.
109 Massachusetts Ave.
Lexington, MA 02173
Tel. (617) 861-8620

MICHIGAN
Detroit
WKM Associates, Inc.
345 Girard
Madison Heights, MI 48071
Tel. (313) 588-2300

MINNESOTA
Minneapolis
Cozzens & Cudahy
Sales Group
John Fluke Mfg. Co., Inc.
10800 Lyndale Ave. S.
Zip: 55420
Tel. (612) 884-4336

MISSOURI
Kansas City
Cozzens & Cudahy
Sales Group
John Fluke Mfg. Co., Inc.
4406 Chouteau Traffic Way
Zip: 64117
Tel. (816) 454-5836

St. Louis
Cozzens & Cudahy
Sales Group
John Fluke Mfg. Co., Inc.
P.O. Box 10013
Zip: 63145
Tel. (314) 423-1234

NEW JERSEY
Newark
SBM Representatives
Sales Group
John Fluke Mfg. Co., Inc.
1519A Stuyvesant Ave.
Union, NJ 07083
Tel. (201) 687-8737

NEW MEXICO
Albuquerque
Barnhill Associates, Inc.
1410-D Wyoming N.E.
Zip: 87112
Tel. (505) 299-7658

NEW YORK
New York
SBM Representatives
Sales Group
John Fluke Mfg. Co., Inc.
28 Hobby Street
Pleasantville, NY 10570
Tel. (914) 769-1811

Rochester
SBM Representatives
Sales Group
John Fluke Mfg. Co., Inc.
4515 Culver Road
Zip: 14622
Tel. (716) 266-1400

NORTH CAROLINA
Greensboro
BCS Associates, Inc.
P.O. Box 9619
1310 Beaman Place
Zip: 27408
Tel. (919) 273-1918

OHIO
Cleveland
WKM Associates, Inc.
16141 Puritas Ave.
Zip: 44135
Tel. (216) 267-0445

Dayton
WKM Associates, Inc.
7913 S. Suburban Road
Zip: 45459
Tel. (513) 434-7500

OREGON
Beaverton
Showalter Instruments Inc.
3800 S.W. Cedar Hills Blvd.
Suite 160
Zip: 97005
Tel. (503) 646-5196

PENNSYLVANIA
Philadelphia
John Fluke Mfg. Co., Inc.
Suite H
1010 West 8th Avenue
King of Prussia, PA 19406
Tel. (215) 265-4040

Pittsburgh
WKM Associates, Inc.
90 Clairton Blvd.
Zip: 15236
Tel. (412) 892-2953

TEXAS
Austin
Barnhill Associates, Inc.
1200 Barton Hill, No. 197
Zip: 78704
Tel. (512) 444-2377

Dallas
Barnhill Associates, Inc.
908 Business Parkway
Richardson, TX 75080
Tel. (214) 231-2573

Houston
Barnhill Associates, Inc.
10606 Hempstead Highway
Suite 132
Zip: 77092
Tel. (713) 688-9971

VIRGINIA
Williamsburg
BCS Associates, Inc.
107 Rich Neck Road
Zip: 23185
Tel. (804) 877-4053

WASHINGTON
Benton City
Showalter Instruments, Inc.
P.O. Box 828
Zip: 99320
Tel. (509) 588-3472

Seattle
Showalter Instruments, Inc.
1521 - 130th N.E.
Bellevue, WA 98005
Tel. (206) 455-4922

WASHINGTON, D.C.
Baltimore
John Fluke Mfg. Co., Inc.
11501 Huff Court
Kensington, MD 20795
Tel. (301) 881-3370

For U.S. areas not listed, contact the regional office nearest you or John Fluke Mfg. Co., Inc., Mountlake Terrace, WA.

Canada

ALBERTA
Calgary
Allan Crawford Assoc., Ltd.
3829 - 12th Street N.E.
Zip: T2E 6M5
Tel. (403) 276-9658

BRITISH COLUMBIA
North Vancouver
Allan Crawford Assoc., Ltd.
116 E. Third St., Suite 203
Zip: V7L 1E6
Tel. (604) 980-4831

NOVA SCOTIA
Halifax
Allan Crawford Assoc., Ltd.
Suite 201, Townsend Pl.
800 Windmill Rd.
Burnside Industrial Park
Dartmouth, NS
Zip: B3B 1L1
Tel. (902) 469-7865

ONTARIO
Toronto
Allan Crawford Assoc., Ltd.
6427 Northam Drive
Mississauga, Ont L4V 1J5
Tel. (416) 678-1500

Ottawa
Allan Crawford Assoc., Ltd.
1299 Richmond Road
Zip: K2B 7Y4
Tel. (613) 829-9651

QUEBEC
Montreal
Allan Crawford Assoc., Ltd.
1330 Marie Victorian Blvd. E.
Longueuil, P.Q. J4G 1A2
Tel. (514) 670-1212

For Canadian areas not listed, contact the regional office nearest you or Allan Crawford Assoc., Ltd., Mississauga, Ontario.

All of the above Fluke Sales Offices carry local stocks of low-cost Digital Multimeters (Models 8000A, 8030A, 8040A), Counters (Model 1900A), Digital Thermometers (Models 2160A, 2170A, 2165A, 2175A) and the Universal Temperature Probe (Model 80T-150). These same products are available from the following distributors:

Brownell Electronics
Atlanta, GA (404) 762-5181
Charlotte, NC (704) 394-4341
Memphis, TN (901) 323-8554
Nashville, TN (615) 889-8230
Orlando, FL (305) 843-6770
Mobile, AL (205) 479-5405

The Mancib Company
Boston, MA (617) 272-9450
Middletown, CT (203) 346-6646

Elmar Electronics
San Francisco, CA (415) 961-3611
Denver, CO (303) 287-9611

Pioneer-Standard
Cleveland, OH (216) 587-3600
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Section 8
Schematic Diagrams

FIGURE NO.	NAME	DRAWING NO.	PAGE
8-1	A1A1 Thermometer PCB Assembly	2175A-1001	8-2
8-2	A2 Display PCB Assembly	2165A-1002	8-4
8-3	A3 Type Select PCB Assembly	2160A-1012	8-6

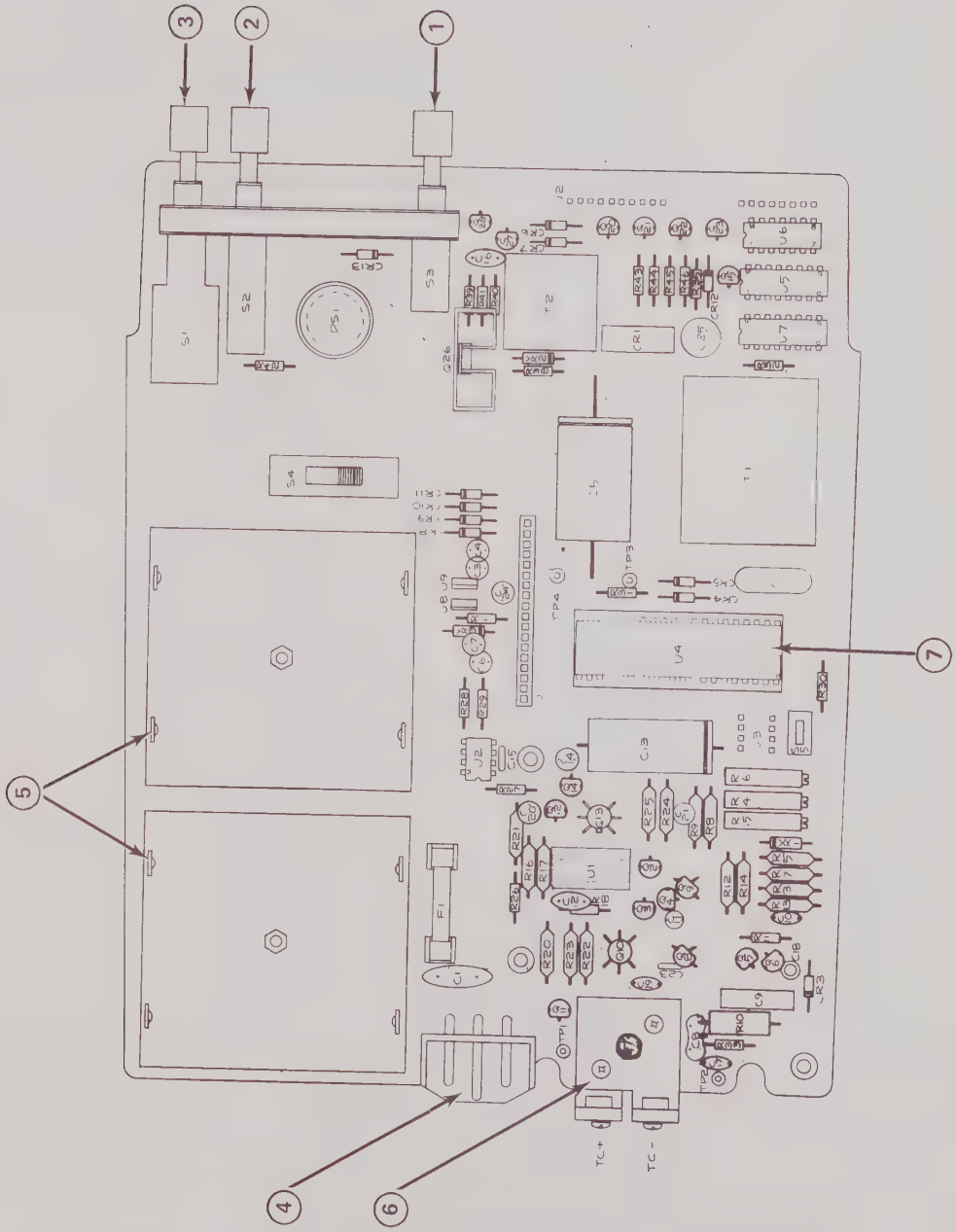


FIGURE 8-1. (1 of 2) A1A1 THERMOMETER PCB ASSEMBLY (2175A-1001)

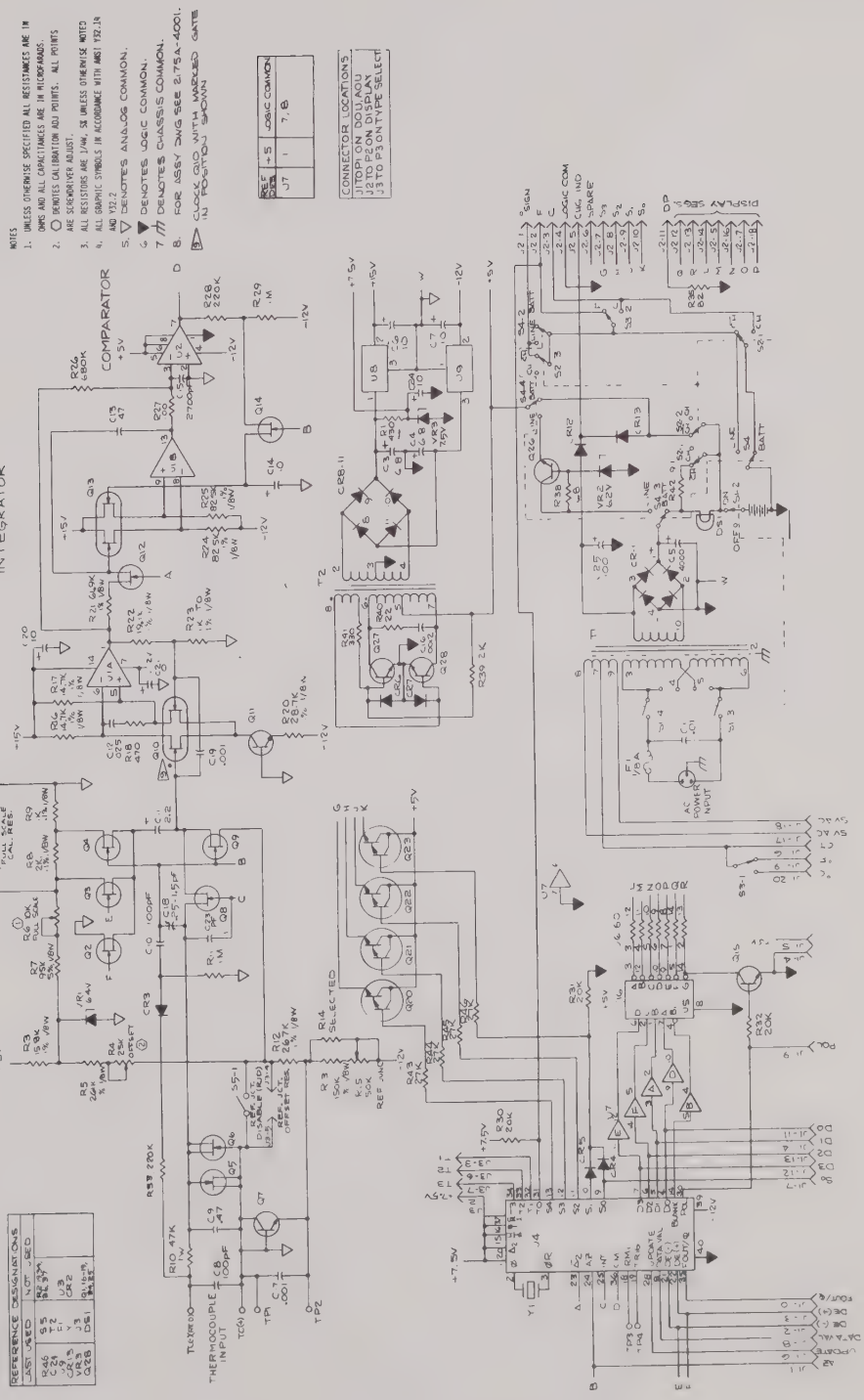


FIGURE 8-1. (2 of 2) A1A1 THERMOMETER PCB ASSEMBLY (2175A-1001)

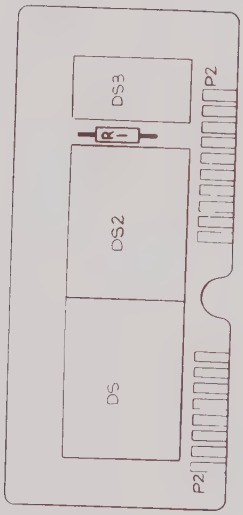


FIGURE 8-2. (1 of 2) A2 DISPLAY PCB ASSEMBLY (2165A-1002)

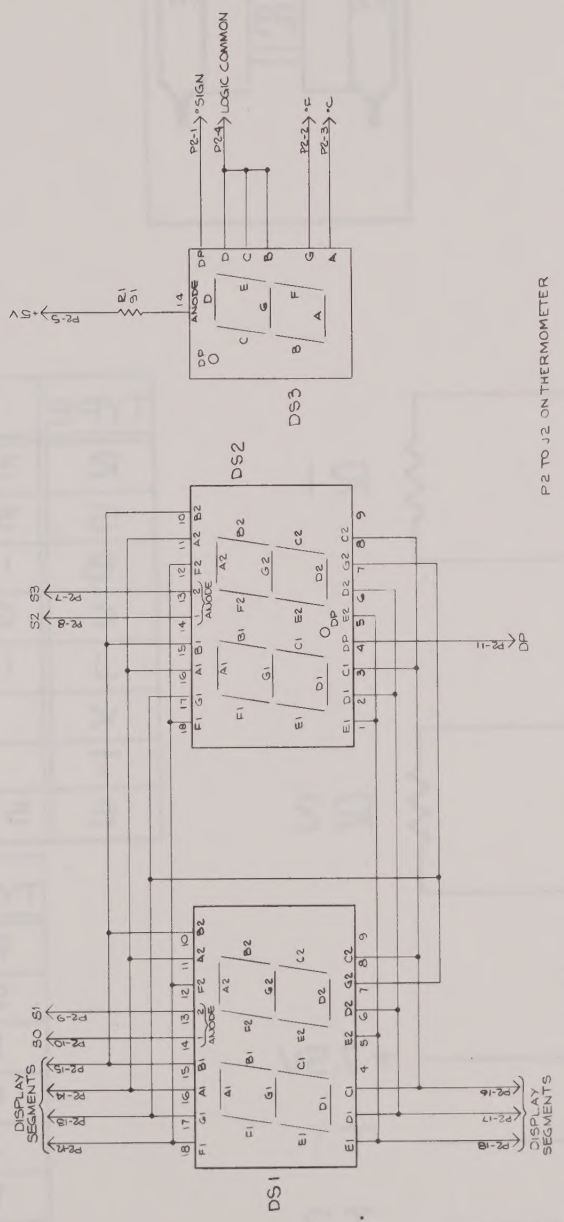
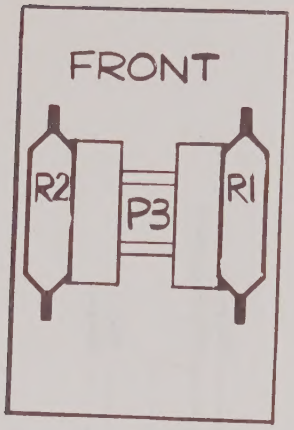
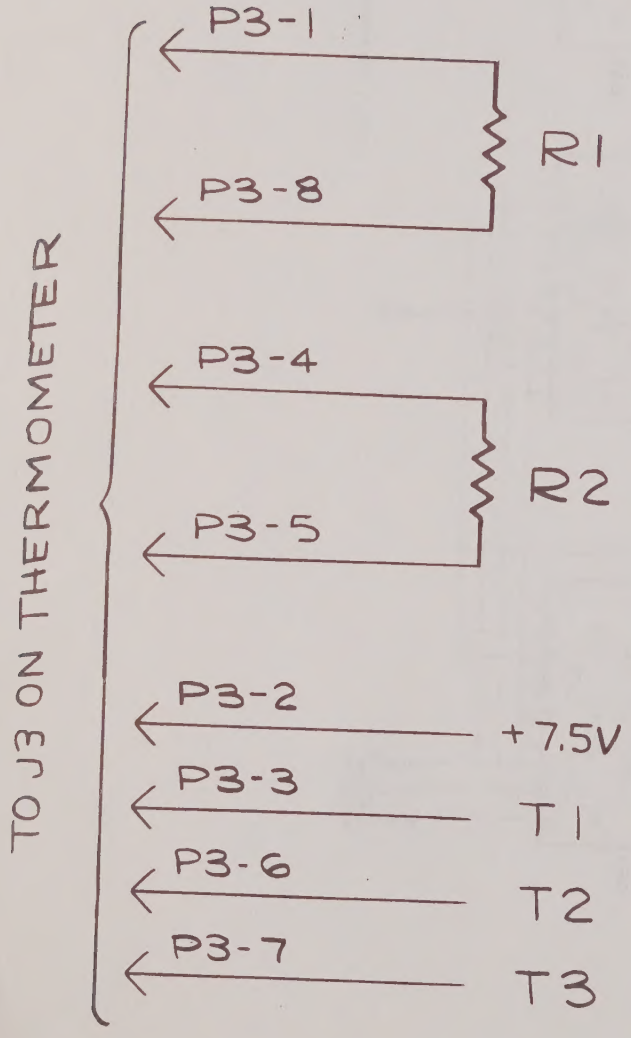


FIGURE 8-2. (2 of 2) A2 DISPLAY PCB ASSEMBLY (2165A-1002)





TYPE	R1	R2
R	324Ω	69.5Ω
S	324Ω	70.0Ω
B	143Ω	JUMPER
C	634Ω	123.5Ω
J	10.7K	619Ω
K	3.74K	481.4Ω
T	3.74K	483.7Ω
E	53.6K	732Ω

TYPE	T1	T2	T3
R	1	1	1
S	1	1	0
B	1	0	1
C	1	0	0
J	0	1	1
K	0	1	0
T	0	0	1
E	0	0	0

1 = +7.5V
0 = OPEN

FIGURE 8-3. A3 TYPE SELECT PCB ASSEMBLY (2160A-1012)